mortal. Here, have we examined *all* animals? If so, man is already examined and a syllogism is *not needed* to prove that he is mortal. But if not, how do we know that the animals which are not examined do not follow a different rule and are not exceptional? If in this case we affirm the predicate, "being mortal" of the unexamined men, we simply *beg the question*. We are on the horns of a dilemma. It is expressed by Carveth Read thus: "If *all* the facts of the major premise of any syllogism have been examined, the syllogism is *needless*, and if *some* of them have not been examined, it is a *petitio principii*. But either all have been examined, or some have not. Therefore the syllogism is either useless, or fallacious."* The difficulty, in short, is that there is either *no inference*, or *a fallacious inference*. The *dictum de omni et nullo*, the dictum on which according to Aristotle the truth of a syllogism formally depends, That which is affirmed or denied of any *whole* may be affirmed or denied of anything contained within that whole, is itself open to such a charge.

If this charge against the syllogism and the *dictum* of Aristotle is a valid one, the show of arguments in mediate inferences will have no cogency. If not, let us see how a syllogism and the *dictum* have to be interpreted.

All animals are mortal, All men are animals, and therefore, All men are mortal. Here if an emphasis be put on '*all*' in the major premise, a petitio principii is involved, for we have not examined all animals, the men (that are animals) are not examined, and the question as to them is therefore begged. There is, however, another interpretation of the major premise. The major premise

*Logic, Deductive, and Inductive, Chap. XIII

need not be read in its denotation, i e, as an enumerative universal. The proposition, All animals are mortal, may imply that there are certain physical peculiarities in the animals that are examined, these are found in the remaining animals and from this we expect that these latter will resemble the former in being mortal. If this interpretation is adopted, the syllogism rests on material evidence, *for resemblance of constitution (having a fleshly body) is a ground of passing from the known to the unknown*, from the animals examined to the animals unexamined. In short, resemblance is a ground of inference Hence as Carveth Read puts it, the Syllogism "begs the question formally, but not materially"

The *dictum de omni et nullo* also will have to be interpreted in a different way It says: "Whatever is affirmed or denied of any whole may be affirmed or denied of anything contained within that whole" If the *whole* is an enumerative whole there is here no mediate inference, it being purely a case of subalternation when we pass from the whole to its parts or to what is included in it; i e, from 'all' to 'some.' If however the *whole* is not known, then the dictum has to be worded differently, and it is thus· "Whatever we have reason to regard as constantly connected with the nature or connotation of a class or class-name, we may expect to be similarly connected with whatever can be shown to have that nature or connotation" Being mortal is connected with the connotation of the class of animals, and men have the nature or connotation of animals, therefore, mortality may be expected in them P is connected with the nature of M, and the nature of M is connected with the class S, therefore P and S may be connected; or in other words, if All M is P, and All S is M, the conclusion follows that All

S is P When thus (differently stated and explained, the dictum takes into consideration the material aspect of a syllogism. This aspect of a syllogism has a close connection with Induction. Hence it is that Induction is necessary (It is presupposed in all Deduction, and it goes beyond Deduction)

4 INDUCTION DISTINGUISHED FROM CERTAIN APPARENTLY ALLIED PROCESSES —(A) INDUCTION AND DEFINITION.—In defining we lay down a general proposition, and in Induction also we arrive at general propositions. The difference between the two lies in the fact that whereas the general propositions which are definitions are *verbal*, those which are inductions are *real* "A body is an extended substance" and "Heat causes bodies to expand," are general propositions. but only the latter of them is an induction, the former being a definition The latter is a real proposition, because the conception of causing expansion is not identical with the conception of heat, whereas the former is a verbal proposition, because the conception of extension is identical with that of a body. So in the proposition, "Man is a rational animal," the conception of the predicate and the subject-term is the same But in the proposition," All men are mortal, " it is not so, for mortality is a different attribute from humanity (Definition and Induction are liable to be confused because in both we arrive at general propositions But the two can be easily distinguished by saying that in definition we are limited to *one* indivisible fact or attribute or set of facts or attributes, whereas in induction we establish a connection between *two* or more facts or attributes. Moreover,(the conjunction or connection of facts or attributes is *tacitly assumed* in definitions, whereas since inductions are inferences, the conjunction has there to be *proved* or *disproved*)

(B) LIKENESS OF GEOMETRICAL DEMONSTRATIONS TO INDUCTION:—In the demonstrations of Euclid there is a certain likeness to induction, for the proof is given with reference to a particular figure, and it applies to all figures of the same kind What is found true with reference to the diagram in question is accepted as generally true Herein there is an *apparent resemblance* to induction. (It is not induction, because in geometry the proof is not based on a particular diagram and then extended generally to all cases. The diagram only gives a concrete representation to the proof which is *general* and not particular. (There is no induction, because there is no progress from particulars to generals; we are *already dealing with general proof*, the figure simply helps the imagination The demonstrations of Euclid, therefore, are not inductive, but deductive. An appropriate name for them would, according to Mill, be "*induction by parity of reasoning*")

(C) COLLIGATION OF FACTS AND INDUCTION —What is meant by a "Colligation of Facts?" Is a colligation of facts an Induction or not? This latter question is hotly controverted by Mill against Whewell. The subject of the controversy is Kepler's discovery that the planet Mars moves in an elliptical orbit The illustration in question will explain what is meant by a colligation of facts Kepler wanted to find out the nature of the orbit in which Mars moved. The motion of the planet could not of course be continuously observed. Detached observations had been made, and the apparent place occupied by the planet noted If these places be joined what would be the orbit of Mars? The reply Kepler gave, after many wrong guesses, was—an elliptical orbit This discovery of Kepler is an Induction according to Whewell, but is not an Induction according to Mill. According to

Mill, what Kepler did was that he guessed an appropriate conception with reference to certain collected facts (colligation of facts) There was no induction, for there was no progress from the known to the unknown Kepler merely guessed a suitable description of a set of facts already observed. The case is a parallel one with that of a navigator, who after sailing round an island, pronounces it to be an island There is no induction here, but only a suitable description, no inference is made at all So Kepler's discovery is not an induction, but only a suitable description based on a happy guess, no inference, no induction

---

Note 1 A BRIEF HISTORY OF THE INDUCTIVE METHOD IN LOGIC —The history of thought is like the history of a nation, in general dependent on circumstances Philosophic tendencies have varied in different ages and different countries accordingly as social and political conditions have changed Every age has its distinctive spirit which guides the thinkers and workers of the time

The early Greek thinkers were moved by a free spirit the spirit of inquiry was not confined in the prison-house of authority and traditions The only care in inquiry, which they needed was, there fore, that consistency should be preserved As Prof Minto observes "The mandate issued to the age of Plato and Aristotle was '*Bring your beliefs into harmony one with another*,' The Logic of Aristotle was suited to this want It deals with Deduction, or the rules of formal correctness Induction is dealt with formally by Aristotle For, he understands by Induction, the summing up of observed particulars The following is an illustration —

'This, that, and the other magnet attract iron,
This, that, and the other magnet are *all* magnets,
All magnets attract iron'

This is simply a collection of particulars, we do not go beyond the particulars, and so illustrated no difference is noticeable between an Induction and a Syllogism

The Mediæval Logicians neglected Induction altogether and gave undue prominence to Deduction They were under a double slavery, to the church and to the Aristotelian dogma. Bacon is fond of referring to Aristotle as a tyrant legislating for the intellectual world The mandate of the Middle Ages was "*Bring your beliefs into harmony with dogma*"

When the rule of dogmatic authority and the church became intolerable, this motto was changed into "*Bring your beliefs into harmony with facts*"

To Aristotle is attributed the origin of Deductive or the Old Logic But who will have the merit of being the founder of the New or Inductive Logic, the Logic which was necessary for the examination of facts Bacon's name is usually given in reply to this question Now undoubtedly the service Bacon did to the development of Inductive Logic, was invaluable He raised a strong note of protest against authority and religious dogmas, showed in outline how progress in Science can be achieved and for this purpose discussed an elaborate method for the interpretation of nature comprising in brief the principles of the several inductive methods with which students of modern logic are familiar, Bacon is therefore regarded as the father of Inductive Logic But if it be meant by this that he was the first to emphasise the importance of the study of Nature as against the study of dogma in general, it is a statement which cannot be supported by facts For this was already done earlier by Leonardo de Vinci, Copernicus, Telesius Gilbert and others As against orthodoxy Bacon urged the argument that "we and not the ancients are older" since "we have gained their experience But in this oft-recurring idea of his Bacon was thinking of a truth that had already been pronounced by Giordano Bruno, who said, "we are older and have lived longer than our predecessors" Moreover, in many respects, Bacon was far behind his age In Astronomy, he could not believe the theory that the earth moves round the sun He rejected Alchemy, but his own theory of the "forms" is sufficiently mediæval in spirit His doctrine of the forms amounted to saying that if you can find out the form or cause of the "simple natures" or qualities of a substance e g gold, you can "superinduce" them on any other substance, e g, silver. This is nothing but alchemy in a new garb, and yet, the

doctrine proceeds from one who was an enemy of alchemy, and "the father of modern philosophy"

The truth is that if we can give the whole of the credit to one who practised induction then we may speak of it, as the Newtonian and not the Baconian method (The first great triumph of the inductive method was the grand generalisation viz, Newton's Law of Gravitation) Locke, the English philosopher applied the same method in scientifically understanding mental phenomena Both Newton and Locke were members of the Royal Society of London Hence as Minto observes ("The birthplace" of the Inductive Method "as a conscious method was in the discussions of the Royal Society of London as the birth-place of the Aristotelian Logic was in the discussions of the Athenian Schools" The merit given to Bacon is thus more than can be justified for he neither invented nor practised the inductive method)

The recognition of Induction as the method used by Scientists and as such its special recognition in Logic came however much later on A century and a half intervened between these thinkers and Mill, who in his "System of Logic" for the first time incorporated scientific method (i e the method used by Scientists) with Logic under the name of induction *

NOTES 2 —THE GENESIS OF MILL'S LOGIC throws light on the peculiar view Mill took with reference to the relation of Deduction and Induction He wanted to see how laws were discovered and *verified* as true in the physical and exact sciences, Astronomy, Chemistry Physics &c Having ascertained the tests applied by them, Mill wanted to formulate them so that they may be applied to Politics Ethics History and Psychology † There is external evidence also in support of this view In his review of Herschell's Discourse on the study of Natural Philosophy (written early in 1832) Mill distinctly says that the uncertainty in moral and social problems is

* The important dates in connection with this sketch are, (1) Bacon 1561–1626 A D (2) Newton and Locke flourished in the seventeenth century (3) Mills "System of Logic was first published in 1843 Philosophy was regarded as the adjunct of Theology by the Scholastics who prevailed from the the 11th to the 13th century

due to the fact that the conditions of proof in them are not those that are recognised in the exact sciences

Mill thus happened to be in search of a scientific method This he discussed in 1843 in his Logic which owes much to Herschell and Whewell whose "History of the Inductive Sciences" gave Mill the final impetus to formulate his Logic[1]

Mill had great respect for the Old Logic When he saw the necessity of extending the methods of proof and verification used by the exact sciences to Mental, Moral, and Political Sciences he felt the need of a new method For this purpose he fell back on Whately's conception of Induction

The Scholastics expressed Formal Induction in the form of an Enthymeme (i e a syllogism with a suppressed premise)

Thus "This that and the other magnet attracts iron, therefore, all magnets do"

The minor premise is here suppressed It would be This, that, and the other magnet are all the magnets

Whately put a particular interpretation on this enthymeme It is not possible to know that the minor premise exhausts all the magnets Since this is not possible, we must take it that the property of the magnets examined belongs to the whole class In that case the argument assumes the following form—

WHAT BELONGS TO THE INDIVIDUALS EXAMINED BELONGS TO THE WHOLE CLASS

The property of attracting iron belongs to the individual pieces of magnets examined,

it belongs to all the magnets

The conception of Whately, Mill caught up, it implied that inference may pass from a number of cases examined to a class of objects, examined as well as unexamined This is *Material Induction* or the Induction with which we are chiefly concerned as distinguished from *Formal Induction* or the induction that is a mere summation

1 (cf Book VI, On the Logic of the Moral Sciences, " System of Logic," Mill)

of particulars The junction between the old and the new is thus brought about by Mill Very tersely, as Minto expresses it "Historically viewed his (Mill's) System of Logic was an attempt to connect 'the practical conditions of proof set forth in Herschell's discourse with the theoretic view of Induction propounded in Whately's'"

NOTE 3 MILL'S VIEW OF THE RELATION BETWEEN DEDUCTION AND INDUCTION —Deduction reasons from general principles to particular facts, induction from particular facts to general principles They are not independent sorts of reasoning The process of thinking is as Mellone observes *the same in both*, i e, to find a place for some fact as a detail within a system In the case of syllogistic, deductive reasoning our system' is partly known beforehand in the form of a general law under which the fact or detail is brought We start having in *our hands* the common thread which unites the various facts But in inductive reasoning we have to *find* the common thread' The major premise of a syllogism is as it were a memorandum of facts, and the syllogism simply interprets it Mill emphasising this view of deduction as the interpretation of a memorandum holds that all inference is essentially inductive "All men are mortal, Socrates is a man, therefore, Socrates is mortal Here our belief in the mortality of Socrates depends on the same kind of evidence as our belief that all men are mortal for, says Mill, the truth of the proposition, "Socrates is mortal' cannot depend on the proposition "All men are mortal which latter cannot be true if Socrates is not known to be mortal Inference therefore is essentially inductive and it is only for convenience, according to him that we call a general induction, Induction, and the interpretation of a memorandum Deduction

Now, in a sense Induction and Deduction are allied, yet they must be thought of as having *separate aims* In his anxiety to connect the new and the old, Mill lost sight of the difference, and over-emphasised the *underlying identity of process* How to establish a memorandum and how to interpret it are different things The aim of Deduction is to give us the conditions of correct conclusion from

[1] Refer to Minto's Introduction, pp 243-272, in his Logic, Inductive and Deductive,

accepted generalities, i e, the conditions of the correct interpretation of a memorandum, whereas the aim of Induction is to lay down the conditions of correct inference from facts, i e, of establishing a memorandum) Of course, the question may arise, if the distinction is to be thus recognized—Is the interpretation of a memorandum an inference at all? There is no addition to our knowledge how then, can Deduction be called an inference at all In the stricter sense it cannot be so called But after all, this is a matter of terminology. Tradition is in favour of Deduction being called an inference It may be so called and the distinction between the two kinds of inference may be suggested by the use of the words, Formal Inference for Deduction, Material Inference for Induction

Note 2 MILL'S DOCTRINE THAT ALL REASONING IS FROM PARTICULAR TO PARTICULAR —

All men are mortal,
Socrates is a man
Socrates is mortal

Here the conclusion according to Mill does not depend on the general proposition, All men are mortal For that proposition, if true, requires that Socrates should be mortal Hence there is no inference from general to particular According to Mill, Socrates is mortal, because other individuals X, Y, Z have died, i e, the truth of the proposition ultimately depends on particular information only Now, an inference from observed particulars to unobserved particulars may be justified at times, but not always When justified, however, the inference presupposes that there are essential points of likeness, i e, both particulars depend on a certain general (likeness implies generality) proposition Minto notes that Mill was betrayed into the statement all reasoning is from particulars to particulars by his peculiar attitude seeing induction and deduction, or the new and the old logic to have the same process as noticed in Whately's conception of Induction

QUESTIONS

1 Define Induction, and show what are the chief essentials of the same

2 How do you distinguish between the Formal and Material aspects of a Syllogism How would you avoid the dilemma, that a syllogism is either needless, or begs the question?

3. Discuss the different statements of the *dictum* of Aristotle

4. What is a definition? How do you distinguish a general proposition which is a definition from a general proposition which is an induction?

5 Was Bacon justly regarded, the father of Inductive Logic? If not, why not?

6 Trace briefly the history of the growth of the Inductive Method Show the genesis of Mill's "System of Logic"

7 Mill, according to Prof Minto committed various errors at the junction of the old and the new logic How and why? What part does Whately's interpretation of scholastic logic play in this mischief?

8 Show the relation between Induction and Deduction How far is Induction necessary How far is Deduction necessary?

9 Discuss the nature of Inference and show how Mill regarded all reasoning as being from particulars to particulars

10 What is Colligation of Facts? How do you distinguish it from Induction?

11 State briefly what is the problem of Inductive Logic

CHAPTER II

FORMAL OR ARISTOTELIAN, AND PERFECT INDUCTION

1. The Aristotelian Induction:—In Deduction the aim of the reasoner is to establish a particular conclusion, and his basis is a general proposition In Induction his aim is to prove a general proposition and this is established when all the parts of which a whole is made up are seen to be true. While Deduction reasons from whole to part, Induction reasons from part to whole According to

Aristotle, the truth about the whole is realised when we go through the truth about the parts. Thus if we know that the skilful steersman is best, the skilful driver is also best and so on, we are in a position to say that the man who is skilful is best in every occupation

THE INDUCTIVE SYLLOGISM:—

From the above account of what Induction meant to Aristotle, it is easy to see that the argument naturally falls into the form of a syllogism Aristotle held that Induction consists in proving the major of the middle by means of the minor. "Induction then, and the Inductive Syllogism, consists in syllogising one extreme with the middle through the other extreme. For example, if B is middle to A and C, to prove through C that A belongs to B " The syllogism is as under —

All C is A,
All C is B,
All B is A

Ordinarily, in the mood Barbara, we prove the major of the minor by means of the middle term. Thus

All B is A,
All C is B,
All C is A.

Here A, the major term is proved of C the minor, through B the middle term But Aristotle while describing Induction, says that we should 'prove that A belongs to B,' 'through C' and that is done in the syllogism in the mood AAA figure III above. Thus

This, that, and the other skilful man is best,
This, that, and the other skilful man are *all* (the) skilful men;
All skilful men are best

Here the minor premise is of the form, All X is all Y, and therefore the conclusion is true Again, since the minor premise is of the form All X is all Y, it can be simply converted, and when it is so converted the argument assumes the form of the mood *Barbara*, which is a valid mood

The expression "proving the major of the middle by means of the minor" needs a little of elucidation In Deduction we prove the major of the minor through the middle The major premiss in the first figure, when the conclusion is affirmative, is of the form All M is P The disputant however may admit the formal validity of the mood Barbara, and yet ask, How is "All M is P" established? To this, the reply would be that this, that, and the other M is P , and this, that, and the other M constitute all M Hence " all M is P " is bound to be correct When this is shown, we have proved the major (P) of the minor (M) by means of the middle (this, that, and the other instance, or part of the middle)

The axiom of this kind of argument, which according to Aristotle is Induction, would be " *What is predicated of every one of the parts is predicable of the whole* " If P is predicable of every one M, it is predicable of all M. If mortality is predicable of every one man (John, Henry, Thomas, and so on) it is predicable of all men. When such a proof is offered, we have proved " the major of the middle by means of the minor" (the particular instances)

2 The nature and utility of the Aristotelian Induction —The Aristotelian Induction is as shewn above really deductive The deductive process of inference in this case will be valid when the minor premise gives a complete enumeration of all the instances of the subject of

discussion. When this is not done, the inference will not be valid. As a mode of "*proof*" Induction in the Aristotelian sense does not differ from Deduction, because it is based on the laws of deduction

What is the utility of such an Induction? If each individual has a certain qualification, property, or attribute, all individuals of the class have it by mere summation Where is the necessity of a tortuous expression of this in the form of a syllogism? The reply to this is that the only utility of the Aristotelian Induction is from the dialectic point of view If an opponent questions a major premise like "all skilful men are best," the easiest and the most efficient method of convincing him of the truth of the proposition is by asking him questions like the following:—

Is not a skilful doctor best ?
Is not a skilful driver best ?
Is not a skilful shoemaker best ?
and so on ;

And are not they all skilful men ? The opponent would have to reply in the affirmative. After the admission of a certain number of particulars, the admission of the whole constituted of those particulars must follow per force. In this way the opponent is bound to admit a general conclusion The only utility of the Aristotelian Induction is therefore from the point of view of Interrogative Dialectic Modern Induction is concerned with the methods by which laws of nature are proved. Evidently such an aim cannot be served by the Aristotelian Induction, for an empirical summation of Particulars is of no use in the discovery of scientific laws

PERFECT INDUCTION:—The Mediæval logicians regarded Induction of the type above discussed as *Perfect*, for there

can be no room for doubt when we argue on the principle, 'what is true of *each* is true of all' Further, they expressed it in the form of an Enthymeme (Inductive Enthymeme) which they expressed shortly in the form.—

This, that, and the other, therefore all
This, that, and the other magnet attracts iron,
all magnets attract iron

This enthymeme is valid when this, that, and the other magnet are all the magnets Whenever it is not possible to examine all magnets, all men, all hot substances, the inductions "all magnets attract iron," "all men are mortal," "all hot substances expand by heat" respectively cannot be validly established All *known* and *unknown* cases must be examined, and then and then only is the enumeration exhaustive If it is not exhaustive and yet an induction is arrived at, it would be an *Imperfect Induction*

3 JEVONS ON THE UTILITY OF PERFECT INDUCTION —Perfect Induction being simply based on enumeration is really speaking not an inference at all Aristotle treated the subject from the dialectic point of view Bacon and Mill ridicule Perfect Induction, and criticise it as being scientifically worthless Jevons, however, defends it on the ground that it substitutes a short for a long statement Thus, it is easier to say that a whole week passed in merriment rather than that Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday did To quote Jevons —

"Mr Mill, indeed, differs from almost all other logicians in holding that perfect Induction is improperly called Induction, because it does not lead to any new knowledge. He defines *Induction* as *inference from the known to the un-*

known and considers the unexamined cases which are apparently brought into our knowledge as the only gain from the process of reasoning. Hence Perfect Induction seems to him to be of no scientific value whatever, because the conclusion is a mere reassertion in a briefer form, mere summing up of the premises. I may point out however, that, if Perfect Induction were no more than a process of abbreviation, it is yet of great importance and requires to be continuously used in science and common life. Without it we could never make a comprehensive statement, but should be obliged to enumerate every particular. After examining the books in a library and finding them to be all English books, we should be unable to sum up our results in the one proposition, "all the books in this library are English books," but should be required to go over the list of books every time we desire to make any one acquainted with the contents of the library. The fact is that the power of expressing a great number of particular facts in a very brief space is essential to the progress of science."*

This is an able defence of the value of Perfect Induction. A short-hand registration of facts has its own utility. Whether such a registration of facts should be called Induction or not is a question of nomenclature. Mill regards it as Induction improperly so called because while merely asserting of a whole that which we have previously asserted of each of the individuals of that whole, we are not progressing in knowledge, there is no passage from the known to the unknown. Whatever the decision may be, it is true that the claims of Jevons are justified. And yet the truth remains, that of the two types of Induction, Perfect Induction and Scientific Induction, it is the latter that has a greater

* Jevons, Elementary Lessons in Logic, p. 214

utility in the discovery and proof of general propositions and rules of science

---

NOTE Difference between Aristotelian Induction and Perfect Induction The difference between these two kinds of Induction is not visible at first sight In both, the result is based on enumeration Yet, whereas the Aristotelian Induction is based on the enumeration of *Species* (or better, sub classes), the Scholastic Induction is based on the enumeration of *individuals* Thus the Aristotelian Induction would be of the following type —

Skilful doctors are best,
Skilful artists are best,
and so on
Hence, skilful men are best

It would not take *individual* skilful men but only the *species* or classes of skilful men into consideration The scholastic method starts with an exhaustive enumeration of individuals The difficulty of obtaining a complete enumeration of individuals (as in the propositions All men are mortal, All magnets attact iron) which is insurmountable in Scholastic logic cannot therefore be perceived in the Aristotelian scheme

---

QUESTIONS

(1) What is the dictum of the Aristotelian Induction? How is it logically related to the *dictum de omni et nullo*, or the dictum of Deductive inference?

(2) Explain the form of the Aristotelian Induction

(3) Show that the Aristotelain Induction is deductive

(4) What is Perfect Induction?

(5) How did the Mediæval or Scholastic Logicians shorten the Aristotelian Inductive Syllogism? Illustrate your answer with a concrete illustration

(6) Is Perfect Induction worthless? How did Mill criticise it? How does Jevons defend its utility? What in your opinion is

the importance of Perfect Induction? Is it more than that of Scientific Induction?

(7) How did Aristotle approach the Question of Induction?

(8) "The Aristotelian Induction has a dialectic utility" Explain this

(9) How do you distinguish between the Aristotelian Induction and Perfect Induction?

CHAPTER III

SCIENTIFIC INDUCTION

1. SCIENTIFIC OR IMPERFECT INDUCTION :—Mill distinguishes his theory of Induction from other theories of which a brief sketch was given in the last chapter. Mill's theory is that in induction we pass from the known to the unknown. He speaks of it as "the process by which we conclude that what is true of certain individuals of a class is true of the whole class, or that what is true at certain times will be true in similar circumstances at all times" It consists in "discovering and proving general propositions." But every process which sets out from a less general and terminates in a more general expression—which may be exemplified by the form, "This and that A are B, therefore every A is B"—is not induction properly so called Mill regards such a process as not an inference at all It is based on an enumeration of individuals The Scholastics regarded it as Perfect Induction. But Mill severely criticizes it on the ground that it does not enable us to make any progress in knowledge. Perfect Induction is not induction and has no scientific value. However, writers who regard logic as purely formal

uphold the Scholastic theory. For example, Hamilton says that Induction is governed by the axiom; "what belongs or does not belong, to all the constituent parts, belongs or does not belong, to the constituted whole." This axiom is the converse of Aristotle's dictum in connection with the syllogism. In the last chapter it was pointed out how Jevons showed the utility of Perfect Induction? The question might occur, why does Mill deride Perfect Induction? Why does he discuss Imperfect Induction? The reply to this question is already given when a brief history of the subject was traced in chapter I. Formal logic had made knowledge stationary. Science had made great strides before the time of Mill. Those who advanced the Sciences did not care and had no inclination to analyse the arguments on which their results were methodically based. If these methods be discovered and made use of in the moral and political sciences many sure results might be established. This being Mill's aim, the position he takes up is justifiable. Perfect Induction is based on formal logic and can secure only formally correct results, imperfect induction is based on material logic and can secure and test progress in knowledge.

2. ILLUSTRATION OF A VALID SCIENTIFIC INDUCTION.— It is pointed out that in Scientific Induction we pass from the known to the unknown or from a limited number of cases examined to a whole class. The proposition "Motion in the particles of a body produces heat" is general. Motion is present wherever heat is present, and the absence of the latter is seen to accompany the absence of the former. Increase motion in the particles of a body and heat will be increased, decrease it, and heat will be decreased. From these considerations we see that the one is the cause of the other, and that the given proposition has a universal vali-

dity Therefore, here is an induction and an induction which is scientific and valid But yet it is to be designated as an Imperfect Induction, because it is not based on an exhaustive examination of all hot substances. This is an impossibility. There can be no Perfect Induction in this case The Induction is arrived at by collecting and testing the nature of hot substances, and cold substances, and examining greater and less degrees of heat in the case of a limited number of instances Thus it is noticed that heat is produced by rubbing (creating motion in the particles of a body), that when water is hot there is motion in its particles, that in dead or motionless matter there is no heat, that when motion of particles is increased heat increases, and so on The conclusion is the induction in question It is based on a limited examination We pass from *cases examined* to *cases unexamined*, and make a generalisation that motion in the particles of a body produces heat This is an Imperfect Induction, because all cases of heat are not examined

3 Induction per Simple enumeration —The above illustration shows what a scientific Induction is It illustrates a scientific induction, because we generalise from a limited number of examined or known cases of heat or absence of heat There is progress from the known to the unknown Hence there is material Induction too. Moreover, the Induction is justified by the tests of a valid inductive inference But the generalisation may be based on a limited number of cases and be not justified by rules of logic. In that case we would have an incorrect or invalid Imperfect Induction One such case is exemplified by what is known as Induction per simple enumeration This kind of Induction consists in affirming a universal truth on

the basis of uncontradicted experience. 'All swans are white' is an induction of this type. The ancients saw only white swans, and from that asserted that all swans are white. 'A generalisation arrived at from, or based on a number of like cases without taking the trouble of searching more cases may by chance turn out to be correct, but there is no reason why it should.' So a quack doctor may cure ninety nine cases of illness, but the hundredth case need not be cured, and a generalisation based on affirmative instances of cure is therefore *precarious*. The exceptions are not searched for or are not found, and it is taken for granted that they do not exist. Hence a causal sequence is supposed to exist in places where it may not. Fowler describes Induction *per simplicem enumerationem*, thus: "I perceive, say in five, ten or twenty cases, that the phenomenon *a* is attended by the phenomenon *b* and knowing of no cases in which the one phenomenon is not attended by the other I begin to suspect that *a* and *b* are connected together in the way of causation." Thus to a fatalist's mind only success due to chance or failure due to chance appeals itself. Cases of chance success or failure are passively received by this mind, and that without the least trouble of searching into other cases contradicting them. He feels *justified from such an experience* in believing that everything happens in a fatalistic way. His generalisation or induction is faulty; it is induction per simple enumeration.

Bacon severely criticised this kind of induction. It is only natural to unscientific minds. "The tendency which some call an instinct, and which others account for by association, to infer the future from the past, the unknown from the known, is simply a habit of expecting that what has been found true once or several times and never yet

found false, will be found true again Whether the instances are few or many, conclusive or inconclusive does not much affect the matter."

4. CLASSIFICATION OF INDUCTIONS :—The different types of Induction dealt with in this and the preceding chapters may be classified as under Science and its progress take their stand on Imperfect Induction, because we examine and can examine a limited number of known instances and from that generalise, or arrive at laws. The subsequent portion of the book will deal with the nature and rules of Scientific Induction

Induction

- Formal
  - i Based on Enumeration of species in a genus, Aristotelian Induction.
  - ii Based on enumeration of individuals; Perfect Induction.
- Material or Imperfect Induction
  - Per Simple Enumeration.
  - Scientific

of this type Every effect has a cause This is a grand generalisation based on many less general results

Fowler's definition is correct It satisfies the two essentials of an induction *viz* (1) a generalisation (2) based on facts (particular or less general)

(2) Fowler also says that Induction may be defined as "*the legitimate inference of the unknown from the known*" In this he agrees with Mill who says that Induction 'proceeds *from the known to the unknown*' This definition has a wrong suggestion We can never pass from the known to the unknown if the latter is entirely unknown We must at least *know* that the unexamined cases have the *same conditions* as those which are examined 'Every effect has a cause' Examine the growth of plants the falling of rain, the occurrence of death and so on The generalisation may be arrived at from an examination of such cases In the future as in the past and present these and similar other things submit to this law This is the force of the Induction From the known it is said we pass to the unknown But the unknown cases, here are known inasmuch as they are all effects in a particular kind of universe Under different conditions the generalisation is not meant to be applied in a different universe A passage from the known to the totally unknown is impossible Heat causes bodies to expand This is a generalisation The unknown cases of heat and the known cases of heat are included in it But the unknown are not totally unknown They may be cases of different substances at different times, and in different places and yet they are known inasmuch as the *conditions* of their existence are the same as the conditions of existence of known or examined cases Strictly speaking we pass in such cases 'from the comparatively known to the comparatively unknown'

(3) Whewell's definition, though not very useful, is worth noticing because of the controversy between him and Mill "Induction," according to Whewell, "is a term applied to describe the process of a true Colligation of Facts by means of an exact and appropriate conception This definition is not correct because it takes no account of the fact that induction is an *inference* and as such is concerned with proof Whewell takes no note of the fact that in induction there is generalisation or inference from facts Unless, however, facts are

ollected and grasped under a proper conception, there can be no *discovery* of an inductive truth The formation of proper conceptions or the facts or a discovery of like points, and the generalisation or nference are two stages of the same process *Mill underrated the former stage, Whewell chiefly concerned himself with that*

QUESTIONS

1 Explain and illustrate the difference between Scientific Induction and Perfect Induction

2 What is Induction per Simple Enumeration ?

3 Assign technical names to the following inferences —

(1) Man, horse, mule, etc , are long-lived,
Man, horse, mule, etc , are bileless
Bileless animals are long-lived "

(2) All the months of the year are of less duration than 32 days, because each and every month is so

(3) Why should I not carry on speculation in Bombay Mr X of Bombay speculated on a grand scale and became a rich man Mr Y did the same thing, and he thrived Some of my friends also succeeded in Bombay in the same way

(4) Classify the different kind of Induction How is it that Scientific Induction is Imperfect Induction ?

(5) Criticise the statement that in Induction we proceed from the known to the unknown Mellone says that Mill s definition that Induction enables us to go from the known to the unknown is " very misleading " Show how far this is so

(6) What is the difference between Mill and Whewell ? How does Whewell define Induction? How far is his definition correct?

(7) Can you show that the results of Scientific Induction are bound to be " probable ? "

(8) Define Induction Show how the Formal and Material aspects of truth differ. With which of these two aspects are you concerned while studying Inductive Logic ?

CHAPTER IV

THE GROUND OF INDUCTION

1 THE GENERAL AXIOM OF INDUCTION —In imperfect or Scientific Induction which is Induction properly so called, we always generalise from experience And yet, the generalisation is based on a limited number of observations By what right is this allowable ? What are the assumptions made by us in this process ? Taking a concrete illustration, the assumptions will be easily visible To make use of an illustration from Fowler's "Inductive Logic." Take two bodies of unequal weight, e. g , a guinea and a feather. Keep them at the same height under the exhausted receiver of an airpump Release them at the same moment, and it will be observed that the two substances will reach the bottom of the vessel at the same time If from this it is inferred that under the same circumstances these or any other bodies, in short, all bodies would when let fall in empty space reach a certain bottom in equal times, here is an inference which is a generalisation from facts observed, *i e.*, an Inductive Inference. The inference is from facts observed to facts unobserved, from the present to the future, and on analysing it, its assumptions will be explicit

Ordinarily we notice that bodies with unequal weights, e g , a stone and a piece of paper do not fall to the ground in the same time when thrown from the same height Bodies fall to the ground, for gravity acts upon them, but they do not fall in equal times, because the resistance of the atmosphere and other circumstances differ in each case In the illustration quoted above, these other circumstances are eliminated, for the guinea and the feather are let fall

in an airless space Only one cause and that the force of gravity can now act upon them. We first observed two bodies with unequal weights reach the bottom of the receiver in the same time We are induced to generalise from this observation, because we notice that one and only one cause operated on the bodies, *viz*, gravity. If it operates again on the two bodies in question or on any other bodies, the *same consequence* will occur This is the generalisation. There is here a two-fold belief. A result is due to *some cause*, and if this same cause operates under the same conditions the *same result* will happen We believe in *causation* and we believe in *uniform causation* or in the Law of Uniformity of Nature, and hence we generalise.

Progress from facts observed to facts unobserved is based, then, on the two assumptions —

(1) The Law of Causation,

and (2) The Law of the Uniformity of Nature

The Law of Causation lays down that 'every event has a cause' It means that whenever something has taken place something must have preceded it and brought it about A man dies The law of causation denies that death took place of its own accord Either it must be some disease or suicide or poison administered by some one else, or murder or some such thing must have brought the death about It is a very ordinary truth 'Poison causes death.' This is a simple generalisation. Some one takes poison and he dies Something precedes and something follows here But no generalisation can be based on mere precedence and succession Just before I commenced writing this line, a carriage passed by my house. The passing of the carriage and the writing of these lines

are antecedent and consequent. From this, however, I cannot form any generalisation since the two events are not connected causally But here is ink and pen and the will to write down my thoughts, the result writing is dependent on them The antecedents and the consequent are here causally connected and are not mere antecedents and consequents Another day, with the same antecedents I may expect the same consequent or consequents Why ? Because there is a causal connection between the two things. But yet, suppose I try to write down my thoughts the next day, and taken up pen and paper with this end If the ink does not blacken the paper, or if the paper does not receive any impression, i e, if the same causes do not produce the same effect, what shall I do? Will my expectations in that case be fulfilled ? Decidedly not In all inductions, whether complex or simple there are two assumptions, (1) the Law of Causation and (2) the Law that the same cause always produces the same effect (The Law of Uniformity).

§ 2 THE UNIFORMITY OF NATURE.—The Law of Causation is one aspect of the Uniformity of Nature This latter principle should be therefore first properly grasped. Its importance also should be noticed In the illustration discussed above, it was seen how the principle is assumed. Mill, following Archbishop Whately regards every induction as a syllogism with the major premiss suppressed, or rather prefers saying that "every induction may be thrown into the form of a syllogism by supplying a major premise" If this is done, the Law of the Uniformity of Nature would become "the ultimate major premiss of all inductions." Thus Mill's Inductive Syllogism would be as under —

All the observed uniformities of nature continue,
That all magnets have attracted iron is an observed uniformity;
∴ It continues i. e., the generalisation or induction that magnets attracts iron is valid and established.

Whately's major premise would be "what is true of some magnets is true of all." But how came we by this major premise, says Mill ? It is not self-evident, for it is not true in cases of unwarranted generalisation. Its truth depends on the basis that a different supposition would be inconsistent with the uniformity which we know to exist in the course of nature · the unobserved cases will resemble the observed ones since nature is uniform. This, therefore, according to Mill, is the real and ultimate major premise.

But how did this principle, namely, the law of the uniformity of nature come to be recognised ? Some regard it as being an *a priori* principle, i.e., a principle not derived from experience but presupposed in all experience. The child that is once burnt dreads the fire the very next time. Why ? The child that has received good treatment from certain familiar persons is always rejoiced in their company. Why ? The reply is simple, the inductive instinct is deep-rooted in human nature. If an animal is not born with such an instinct, it can withstand the struggle for existence with the greatest difficulty, and in the majority of cases perhaps it would not. That the law of the uniformity of nature is an ultimate postulate of experience is very easy to show Its proof is that we cannot but act on it It is not easy to prove it in any other way. As Prof. Minto says: "It is simply an assumption on which we act.

If any man cares to deny it, there is no argument that we can turn against him. We can only convict him of practical inconsistency, by showing that he acts upon this assumption himself every minute of his waking day If we do not believe in the continuance of observed uniformities, why do we turn our eyes to the window expecting to find it in its accustomed order of place? Why do we not look for it in another wall? Why do we dip our pens in ink, and expect the application of them to white paper to be followed by a black mark?"

Others regard the principle as being derived from experience When however it is stated that the law of the uniformity of nature is derived from experience, it should not be understood that it is based on a Scientific Induction. The Induction on which this grand generalisation depends is only Induction per simple enumeration It is based on a series of uncontradicted experience It has not been resolved into, or as Fowler says "possibly does not admit of being resolved into, facts of causation." Hence the law of uniformity of nature is not a Scientific Induction, but only *Induction per Enumerationem Simplicem.*

In fact we only proceed on the belief that nature is uniform It is the foundation of the different sciences But in many ways Nature does not *seem* to be uniform Fine weather this morning is not an index of fine weather to-morrow morning If there is abundance of rain this year, it may be that next year there may be famine Fortune is proverbially capricious in the bestowal of her gifts The course of trade is full of surprises The inability to see such things as these is very often the source of wrong inductions, e g, the inductions "all swans are white" made by Europeans not many years ago

NOT *a* UNIFORMITY BUT *Uniformities.*—In the midst of infinite diversity there is a general uniformity or regularity in the chain of phenomena in the world. The uniformity that presents itself in the world is not strictly speaking *a* uniformity, but a complex fact, being a resultant of the co-existence of many partial *uniformities* Thus if A is followed by D, B by E, and C by F, we shall have the sequences A B —D E, A C —D F, B C—E F, and A B C—D E F, provided the simpler sequence of D after A, E after B, and F after C was a causal one. The sequence A B C—D E F would be regular and yet complex It is not uniformity, but uniformities. Thus, if poison is taken and death follows, the result is not simple but complex, since it depends on the properties of the poison, and the laws which the human organism obeys. Here, there are two uniformities If the poison is a chemical compound, the number of uniformities is more than this.

Mill says that uniformities which are in this way complex are *laws* but *not laws of Nature* Wherever there is regularity, there is law. But all laws are not laws of Nature. The latter expression is reserved for the fewest general propositions from which all uniformities in the universe might be deductively inferred Derivative uniformities are thus excluded; the complex laws on which they depend are not to be termed laws of Nature. The term 'Law of Nature' then, in the strict sense, stands for the ultimate uniformities of nature, e g , the law of Gravity, the law of the Conservation of Force

4 DISTRIBUTION OF UNIFORMITY OF NATURE UNDER THREE MAIN BRANCHES :—Bain enumerates three heads of uniformity. *co-existence, causation,* and *equality* These three

uniformities are established by induction, but all of them are not established by scientific induction

Under the head of Uniformities of Co existence Carveth Read puts the following *

(A) The Geometrical. In a four-sided figure, if the opposite angles are equal, the opposite sides are equal and parallel Here there is co-existence of certain facts in space, namely, equality of angles and equality of sides The co-existing facts are independent, for the one does not *cause* the other, nor are they derivative' *i. e*, caused by something else They are simply mutually involved

(B) Universal Co-existence among the properties of concrete things, chiefly the co-existence uniting the properties, Inertia and Gravity Inertia has nothing to do with Gravity It means resistance to movement, and force when moved. In all material bodies Inertia and Gravity co-exist, they are seen to be universally co existent "Equal weights, (which are the estimate of Gravity), are equally resisting to a horizontal impulse (the measure of Inertia) or to a vertical impulse in the balanced condition " All inert matter gravitates, and the force of Gravitation is proportional to the Inertia The co-existence of these two in concrete things is thus always to be found The two properties are inseparable yet independent for they are not dependent on one another, nor are they the effects of any common cause.

(C) Co-existence due to causation The relative position of the books on my table is dependent on my will So long as the order is untouched it will continue The relative position of the houses in a street, of the trees in a garden, of rivers, mountains and so on, is of this type. If it is disturb-

* Chap XIII, Logic, Deductive and Inductive

ed by man, or by some force of nature, it will disappear, and with it the uniformity of co-existence.

(d) The co-existence of properties in natural kinds: Thus gold is a natural kind, and in it certain attributes co-exist or co-inhere These are its specific gravity, crystallisation (cubical), tenacity, fusibility (*i e*, its peculiar melting point), colour and lustre, electrical conduction, atomic weight, combining properties (that it is acted on by *aqua regia*) These eight attributes co-exist in the substance gold, and they are all essential because we cannot derive any of these eight attributes from any other. Similarly the natural kinds, elements like oxygen, platinum, and so on, compounds like water, gunpowder, salt, and so on, the different species of plants and animals are all groups of co-inhering attributes. On a knowledge of these, depend the classificatory sciences The groups of co-existing properties of this kind may be conjectured to be due to causation, but very often the causes are unknown and cannot be traced. Thus no cause can be assigned why in gold the eight properties above mentioned co-exist Why does blackness co-exist with the other properties of a crow? This and such other questions with reference to the co-existence of the properties of natural kinds are almost insoluble Co-existences of the (*d*) type are therefore sufficiently unique to form a class by themselves

(e) Co-existences of quite an unaccountable way: There are certain co-existences which are not traceable to any cause Nor are they referable to any one species or genus or order as in the (d) class above (Thus, most mortals are white, scarlet flowers are wanting in fragrance.) Why? The flowers are of different natures, the metals are

different natural kinds No reason is assignable Hence class (e) is different from class (d).

The proof of uniformities of co-existence not known to depend on causation is simply uncontradicted agreement in nature. Here is an induction of the type known as Induction per simple enumeration We find that these uniformities hold good througnout the whole compass of observation Thus Inertia accompanies Gravity throughout the whole globe It applies to the solar system By strong analogy it applies even to the distant stars. We only have the cases of agreement and from that we generalise in this case. Hence this is simple enumeration, and the Induction is not based on causation or scientific elimination, hence it is induction per simple enumeration

Under the head of uniformities of Causation may be put down all the uniformites of Science The refined rules of Logic (Inductive Methods) are applicable to these kinds of uniformities and an exhaustive treatment of them follows in the succeeding pages

The proof of the uniformities of Causation is uncontradicted experience Nothing like causation which is not uniform is ever seen The experience is uncontradicted, and hence the principle accepted. This is Induction per simple enumeration, which is generally regarded as precarious. That "all swans are white" was an Induction of that type It is a generalisation of an observed fact from the absence of any known instance to the contrary, subsequent experience may refuse to confirm such an induction and hence it is precarious But though even the general Laws of Causation and uniformity of Nature are themselves according to Mill proved from experience on the ground of Induction per simple enumeration, yet he justifies the

proof on the reasoning that the precariousness of the method of simple enumeration is in an inverse ratio to the largeness of the generalisation The principles in question have a very wide applicability. At every step of knowledge we meet with instances of their truth. As the sphere widens the unscientific method of making a generalisation from simple enumeration of observed cases of likeness becomes less liable to mislead.

Under the third aspect of uniformity, Bain puts down the uniformities of Equality and Inequality On them depend the truths of Mathematics The proof of these uniformities is also based on Induction per simple enumeration.

Bain's three branches of uniformities are (1) of Co-existence, (2) of Causation, and (3) of Equality and Inequality. The general condition of these three special uniformities is (4) the law of the Uniformity of Nature, and the general condition of the uniformities of causation, i e., special causation, is (5) the Law of Universal Causation. Fowler, therefore, mentions these two inductions in addition to Bain's three branches of uniformities These five are the aspects of Uniformities with which Inductive Logic has to deal It is however Inductions of causation with which Science is mainly concerned. The refined rules of Inductive Logic are necessary to test these generalisations and are applicable only to the uniformities of Causation Hence the concept of a cause needs a careful examination. This will be the subject of the next chapter. The uniformities of Co-existence are involved in the problem of classification, and those of Equality and Inequality in Mathematics. The Law of the Uniformity of Nature is the basis of all inductions, without its help we cannot argue from the past to the future, or from the known to the unknown.

QUESTIONS

(1) What are the general rules on which any induction is based

(2) What is the ultimate major premise of all inductions?

(3) Is it possible to prove the Law of the Uniformity of Nature If so how? Is Mill's proof strictly speaking a proof at all Show that there is here a show of movement in a circle Inductions being based on the Law of uniformities of Nature, and this Law itself on observed uniformities

(4) Which are the main branches of uniformities of Nature? Fowler adds two general laws of uniformities to the three special aspects enumerated by Bain Why?

(5) Which are the main aspects of the uniformities of Co-existence?

(6) Is Induction per simple enumeration totally worthless? Show how its precariousness may be avoided in part.

(7) Examine the relation of Causation to the uniformity of Nature

CHAPTER V

CAUSATION

1 Causation, a specially important aspect of the Uniformities of Nature —That every event has a cause is a uniformity of Nature There are various aspects of the uniformity of Nature three or four or five of which were taken a note of in the last chapter as being involved in Induction Causation is a specially important aspect of the uniformity of Nature for two reasons (*Firstly, Causation is involved in many other uniformities* It is is involved in the unifomities of *Co-existences due to itself*, e g, the position of the houses in a street is an illustration of co-existence, and the co-existence has a cause, it will continue to be the same so long as there is no disturbance by fire, earthquake, and so on The co-existences of properties in natural kinds, e. g, plants, animals, and inorganic bodies must if possible be traced to causes It is the aim of science to do this It

is difficult to achieve it, and is hardly achieved in many cases The co-existences which cannot be traced to any causes whatsoever or which do not admit of a methodical inductive treatment (e g., scarlet flowers wanting in fragrance) are limited, and so far as Inductive Logic is concerned do not deserve to be seriously taken a note of, for it is the aim of Logic to render knowledge methodical Secondly, *Causation provides*, as Prof, Bain observes, *a comprehensive uniformity*, whereas this is not so with other uniformities. Independently of causation, the uniformities of co-existence can be proved *only piece-meal* Each uniformity of co-existence stands on its own basis No one uniformity of that type helps us in proving another Thus gold has certain properties and diamond has certain others By observation we can generalise about the properties which co-inhere in gold, and those which co-inhere in diamond, but we cannot include them under a comprehensive uniformity Whereas, in the case of causation we can go on including one generalisation under another, and that under a third and so on, till at last we arrive at a very comprehensive uniformity e g, the Law of Gravity, from a knowledge of which minor causations may be predicted deductively. As Prof. Bain says "there is a blankness of resources in regard to the proper laws of co-existence; their Logic is speedily exhausted" This is not so with reference to causation, because scientifically it is always possible to conceive a cause of a cause, and a cause thereof, and so on till at last we find out broad or comprehensive causes from a knowledge of which certain results may under certain circumstance be deductively, rationally, or without the help of experience predicted Just as the uniformities of Co-existence are piece--meal, so the uniformi-

ties of Equality and Inequality are so. The mathematical truth, "Things equal to the same thing are equal to one another" is easily verifiable Having found it to be true, we may apply it to any case whatsoever. So we take the other proposition, "If equals be added to equals, the results are equal" Both of these propositions are true, but they are detached It is not possible to bring them under a law of generalisation more comprehensive than themselves. Whereas as we have seen in causation we can always go on enlarging our generalisations Poison causes death, disease causes death, a sword-cut causes death Why? In a way there is a cause common to all these cases, *viz*, the peculiarities of the physical organism This then being so, causation is an aspect of the uniformity of Nature which specially concerns us in the problem of Induction (generalisation from experience)

2. WHAT IS A CAUSE?—The concept of a cause is one that is used very freely by ordinary men as well as by men of science. Rarely, however, do people make use of it with scientific accuracy The tendency of the human mind is to connect interesting events whether there be any connection between them or not Very often prejudices originate from such a tendency A is followed by B; ∴ event A is regarded as the cause of event B If there is sequence, we imagine there is *consequence* But sequence is not consequence *Post Hoc, ergo, Propter Hoc*, i e, "After therefore, Because of" is an ordinary inductive fallacy. Many superstitions are fostered by fallacious inductions involving this kind of reasoning So a man may have a scorpion-bite. The ordinary superstitious practice consists in seeking the cure in some incantations There comes the man with his miraculous power, he mutters some formulæ,

rubs the bitten portion of the body gently and after four or five minutes in some cases the pain lessens The belief is engendered that the muttering was efficacious or that it was the cause of the relief. *Post Hoc*, therefore, *Propter Hoc*, the cure follows the muttering, and hence the latter is the cause of the former. The two, however, are not connected as cause and effect The real cause is partly the rubbing, and partly subjective, namely, the idea that one is being treated by an efficacious remedy, which goes a great way towards bringing about the reduction in the pain. Mere sequence is not therefore causal sequence

This very inductive fallacy is involved in the homely illustration of the काकतालीयन्याय (the rule of the crow and the palm-fruit) Merely because a crow sits on a palm-tree, we cannot assign this as the cause of the falling of the palm-fruit, supposing the fall is immediately followed by the crow's sitting on the tree This is not a causal sequence, but only a casual co-incidence. The palm-fruit would have fallen even without the sitting of the crow; and palm fruits do not fall whenever crows sit on a palm-tree

Mere antecedence and sequence will not therefore do. The casual antecedent will not be uniformly followed by its consequent The causal antecedent is however always followed by its consequent, e g, the creation of heat is always followed by expansion in a metal The cause is thus an *invariable* or *uniform* antecedent But not all invariable or uniform antecedents are causes The occurrence of day invariably precedes the occurrence of night; yet the former is not the cause of the latter. When there is explosion in a gun, a flash of light invariably precedes the report heard at a distance; yet the flash of light does not cause the sound. Whenever quinine cures ague, the bitter taste

of quinine invariably precedes the physical cure, and yet the creation of the bitter taste is not the cause of the physical cure Why? The reason is that though the antecedent in each case here is invariable, yet it is not *necessary*, *indispensable*, or *unconditional* for the effect concerned. Day may not precede night and yet night might be conceived to happen If the sun disappears, or loses light-giving property or the earth ceases to turn round its axis, there would be no change of day and night we may conceive eternal day or eternal night Without the ante cedent given, day, night may happen When a gun is exploded the occurrence of a flash of light may be prevented, and yet the sound *will be heard* By taking a sugarcoated quinine tabloid, the bitter taste may be prevented and yet the effect, cure, *will happen* The antecedent in each case therefore is not *indispensable* or *unconditional* *Whatever antecedent can be omitted without prejudicing a consequent is not an indispensable or unconditional antecedent* But if the movement of the earth on its axis round the sun does not take place, the sequence day followed by night *will not happen* If the ignition of the powder does not happen, the report *will not be heard* If the qualities of quinine be not absorbed in the body the cure *will not happen* So *whatever antecedent can not be omitted without the disappearance of the consequent must be an indispensable or unconditoinal antecedent* (*or even a part of it*)

The causal antecedent is an unconditional or indispensable antecedent as analysed above Of course it will be also invariably followed by the effect But if the *unconditionality* of an antecedent be established with reference to a certain consequent, it is enough, this itself enables us to infer causation An antecedent may not be shown or proved to be invariable, yet it is causal if it is proved to be un-

conditional Its invariability depends on its unconditionality and never *vice versa*. The supply of oxygen is the unconditional antecedent of the burning of fire. For, any part of air except oxygen (e g nitrogen) may be left out and yet burning *will happen*, but if the supply of oxygen is left out, burning *will not happen* The unconditional dependence of the burning of fire on the supply of oxygen may be proved by a *single* experiment, it is not necessary to see the sequence often or invariably in order to convince us of its causal nature. But as it is an unconditional sequence we are sure that whenever oxygen is supplied the process will take place.

But what is an antecedent? The pulling of the trigger is, we say, the cause of the loud explosion, because the antecedent is here unconditional. When the trigger is pulled the explosion occurs, without it, it would not occur But together with the pulling of the trigger, other things are necessary These other things are the quality of the powder being a fit one, the condition of the barrel proper, the atmosphere favourable, and the proper arrangement of the percussion-cap in connection with the powder. All these are factors contributing to the result, the pulling of the trigger is the last thing necessary It is something *done* at a time when the other things *remained* favourable. The favourable things were *static*, it is *dynamic* In popular language the pulling of the trigger is mentioned as the cause and no notice is taken of the static antecedent or the *conditions* Generally only antecedent and consequent *events* interest us, and hence, in popular language only one out of many antecedents, and that the last and the dynamic one, is selected and pointed out as the cause of the event The causal antecedent is when properly analysed often a *group* of certain conditions and events.[1]

In short, a cause is an invariable unconditional antecedent of a certain event which follows it. Its unconditionality determines its invariability, the latter being a sign of the causal nature of a sequence but not the essence of the same. By an antecedent is meant the *group* of conditions and events which together determine a consequent. Generally there is a sequence and an immediate sequence in the causal relation, and so, the cause is an *invariable, unconditional, immediate* antecedent of a certain event which follows it.

§ 4. THE TIME ELEMENT IN CAUSATION.—How far is sequence an essential aspect of causation? Is the cause an antecedent at all? *Generally* cause and effect are spoken of as antecedent and consequent. But there are cases in which the two are co-existent. The weight of the atmosphere causes the mercury in the barometer to rise. Contact with fire produces a burning sensation and that with water wets substances. Hydrogen and oxygen combine in the proportion of two to one and water is formed. A weight in one scale of a balance keeps an equal weight in another balance suspended. The cause and effect in these cases are simultaneous. If such cases are considered, the cause is not an antecedent; it is simply the assemblage of phenomena which occurring, some other phenomenon invariably and necessarily commences or has its origin. But even apart from such cases, it is not proper to consider antecedence and sequence *in time* as essential to the causal relation. An antecedent and a consequent are *two* phenomena, the cause and the effect are not two distinct phenomena. They are *two aspects* of a phenomenon or rather *a process which is one and continuous*. The full development of the cause *is* the effect, at no moment of time is there a gap between the cause and the effect.

Practically, however, *this question* of *the time element is immaterial* For the effect never precedes the cause and whenever there is any doubt as regards the point, which of two phenomena is the cause and which the effect we solve it by finding out the event which preceded the other, the event in which there has been waste of energy or power, and speaking of it as the cause.

§4 THE DEFINITION OF A CAUSE —Bearing the above analysis in mind, a cause may be strictly defined as a phenomenon or an assemblage of phenomena which *unconditionally* (or indispensably) determines the occurrence of another phenomenon. Roughly or loosely it may be defined as an invariable, immediate, unconditional antecedent of a phenomenon which follows it

§5 THE CAUSE AS POPULARLY, SCIENTIFICALLY, AND PHILOSOPHICALLY ANALYSED:—Dr. Venn says that we can trace the full development of the conception of a cause through three stages* Firstly there is the *popular notion* of a cause on which depends the inductive reasoning of the savage and the uncultivated classes Secondly, there is the amendment of this view as *represented by the logicians and physicists*, chiefly, Hume, Brown, Herschell, and Mill Thirdly, there is the *most scientific and precise conception which applies only to hypothetical cases*, and it is therefore, not useful or practical like the second one Let us take the first two of these conceptions, one by one, and see how the concept of cause is scientifically analysed

I According to the popular conception, only one, antecedent is singled out from amongst many, and that is connected with one consequent. The two are regarded as

* Empirical Logic, p 51

cause and effect, provided there is invariability of succession Thus a man takes poison and dies The cause of death is the taking of the poison Without it the death would not have occurred There is antecedence and sequence and it is invariable. So if a man's foot slips and he falls and is injured, it is popularly said that the cause of the injury is the slipping of his foot So a battle is fought, a victory won, and the name of the victorious battle is connected with the name of a particular commander-in-chief, as if Napoleon or Wellington or whoever he may be is the cause of a particular victory This is the way in which language is ordinarily used Now there are reasons why only one antecedent is selected as the cause, and one consequent as the effect of the many antecedents Only the *dynamic* antecedent attracts our notice and is *interesting* to us. The properties of the poison, the condition of the human organism, the quality of the food, and the atmospheric condition, all must operate together in bringing about the result death But the quality of the food, &c are stationary things, they are *conditions*, the change is apparently brought about by the taking of the poison, which is an *event* or which is dynamic Hence we are attracted by it, and we speak of it as the cause of the death, though really all the antecedents together are the cause. Dr. Venn explains the popular attitude in a two-fold way "Either the neglected elements are so obvious and so necessary that their presence may be taken for granted without express mention, or they are so trivial that, for anything they are supposed to contribute towards the result it was considered that they might actually be rejected."* Thus in death due to poison, a particular condition of the organism is obviously neces-

* (Empirical Logic, pp 53-54)

sary, for surely no result would follow otherwise. In the case of the explosion, the condition of the atmosphere may be regarded as trivial for it does not count for much unless it be exceptionally adverse Again, we select only one consequent, and speak of it as the effect The reason of this is that we are only concerned with the one under investigation. It is purely a matter of chance why we select this one consequent. Thus the taking of poison causes death. The consequent mentioned is one, *viz*, death. We are concerned with life-activities ordinarily, and hence, speak of their ceasing. But if we happen to have a chemical aim we might mention the change in the properties of the human organism after the taking of poison as the consequent or the effect

II Mill's idea of a cause is based on, and an impovement of the popular view He first defines a cause as the *invariable antecedent* of an event which follows it and which is termed the effect. Wherever there is invariable antecedence and sequence between two phenomena, the invariable antecedent is termed the cause, and the invariable consequent, the effect. "Heat causes bodies to expand" Heat and expansion are antecedent and consequent; the relation between the two is invariable, for heat is always followed by expansion. Further, Mill shews that the invariable antecedent is not *one* antecedent as is popularly conceived, but is a *sum-total of conditions which may be positive as well as negative* Philosophically speaking, says Mill, we have no right to give the name of cause to one only of the many antecedents which invariably precede a consequent So in the illustration of death due to poison we noticed many antecedents They were all positive. Negative conditions are simply assumed as already existing, e. g, the person

not having taken a curative medicine in right time. So we might take the case of an incendiary setting fire to a house at midnight. The burning of the house is due to the mischief of the incendiary The igniting of some portion of the house would be regarded as the cause from the popular point of view But among the other necessary antecedents we must take note of the inflammable nature of the materials of the house, the conditions of the atmosphere and so on These are all positive conditions Among the negative conditions we must take note of the absence o persons to detect and stop the mischief- maker in his incendiarism "The cause, then, philosophically speaking, i the sum-total of the conditions positive and negative taken together, the whole of the contingencies of every description, which being realised, the consequent invariably follows " Finally, Mill shows that though the second definition is more precise than the first, yet it is not still an adequate definition, *invariable* sequence is not causal sequence unless it is also *unconditional* sequence The sequence of day and night is invariable, yet not causal because there is no necessity in the connection, both day and night being contingent on certain other phenomena Bearing the full analysis of Mill's idea of a cause in mind, we may take as his definition the following A cause is "*the invariable, unconditional antecedent*" *of a given phenomenon*

Now in his analysis of the concept of a cause Mill goes beyond the popular point of view by insisting that we should enumerate the whole group of elements or *all* the elements which go to make up the antecedent, (and by saying that the antecedent should be unconditional)

Another respect in which according to Dr Venn, a logician insists upon an improvement of the popular con

ception of causation is this The effect *immediately* follows the cause The relation between the antecedent and the consequent is a *close* one in all causal sequences This improvement follows from Mill's qualification that the cause is the invariable, *unconditional* antecedent, immediacy of sequence being impossible where the sequence though invariable is yet dependent on some condition other than the presence of the antecedent In the illustration of death due to poison, the *immediate* antecedent is the chemical change in the poison absorbed, and the organism affected. This is the cause of death and this antecedent is the unconditional antecedent or this antecedent when once it comes into existence does not require the presence of any other condition with it

III The third stage according to Dr Venn is that in which speculative interest gets the upper hand and you lay down an analysis which is theoretically acceptable but is not of practical use, for the conditions of the definition cannot be actually realized. The law of causation in its most precise form would be . "Given that in any two instances the *precise sum-total* of antecedents *recurs*, so will the sum-total of *immediate consequents*, and conversely." The conditions of this formulation cannot be realised, and hence, however good it may be theoretically, it is not a formulation which is of practical utility

All causation would according to this analysis be *reciprocal* having known the cause, we may know the effect, and *vice versa* The concept arrived at would be the concept of a cause *commensurate* with the effect In this sense a cause will have only one effect, and an effect only one cause. Thus the *general* conditions destructive of life would be

the cause of death *generally* death must follow them, and they must precede death The specific condition (the attack by plague-bacilli) will cause the specific death, namely, that due to plague· here causation is reciprocal. The *scientist* is mainly concerned with the *practical* aim of *producing* or *preventing* certain effects, *whatever* the cause specifically may be· his aim is satisfied with acquainting himself with one out of a *plurality* of alternating causes he need not and does not concern himself with *reciprocating* causal relations, unless it be for *speculative* purposes

Inductive Logic regards the second of the three analyses of causation as the most serviceable

6. Quantitative Aspect of causation –In the preceding section the qualitative aspect of a cause is analysed. Quantitatively cause and effect are equal The effect is nothing but the cause redistributed Hence *as to matter*, the two are *identical* So, when a seed grows into a plant and that into a big tree, no matter is added to the already existing matter of the universe The seed develops into the plant by absorbing earth and moisture Something is lost in one direction, and something gained in another Experimentally it may be shewn that the quantity of matter replaced is the same as the quantity of matter gained Thus Oxygen and Hydrogen form water, the effect water is quantitatively equal to the cause Oxygen and Hydrogen The law of "Conservation of Force or Energy" is helpful in viewing causation from the same point of view The law in question is that force is never lost, extinction of energy in one form is accompanied by creation of energy in another form To quote Bain· "If we suppose a portion of the universe isolated so that it neither gives nor receives energy from without, then the principle of the Conservation of

Energy asserts that the sum of the kinetic and potential energies within this material system is constant and unalterable. The actions and reactions of its parts can only vary the *relative proportions* of kinetic and potential energies, but not their *amount*" Taking this scientific view into consideration, Bain analyses a cause into "a moving power" and a "collocation" of circumstances (Potential Energy). Thus a running stream is the moving power of the turning of a mill. But the moving power itself will not do. There must be a suitable collocation or connection for bringing the water to bear upon the machinery Sufficient energy of grinding the corn comes into existence because of the collocation The energy of the moving or inciting power may seem weak, but in the midst and through the help of a suitable collocation, the energy requisite for the production of the effect will be forthcoming This may be seen more easily in the illustration of a demagogue inciting a whole mob to riotous action The moving power is apparently weak, namely, the words of the demagogue. But they are addressed to the mob, which gets riotous and is stirred up to mischievous activity The collocation is the will and the nervo muscular power of the different individuals of the mob Here there is sufficient energy to account for the result, though in the moving power, namely, in the words of the demagogue, there was apparently no such power.

7. AGENT AND PATIENT:—In the universe, certain things seem to the eye to be apparently at rest and certain things in motion Some things are spoken of as active and others as passive. As a matter of fact, however, there is no rest in Nature, all things are in a constant flux, and the distinction between agent and patient is only a relative one. Thus, to take the illustration of a man delivering a lecture and bringing about a certain conviction in his audi-

ence, it is the speaker it may be said, who is active and the audience that is passive By an incident of language the term cause is limited to the agent and is refused to the patient The patient is the scene in which the effect takes place. Being included in the phrase by which the effect is spoken of, it appears rather incongruous to speak of the patient as the cause of the effect Thus, the conviction in the audience is partly due to the speech of the orator, and partly to the mental susceptibility of the audience itself. The result conviction is partly due to the mental susceptibilities of the audience They are part of the cause, but being connected with the effect, we speak of them as things acted upon As a matter of fact agents and patients act and react on one another The agent acts on the patient, but so too does the latter on the former The susceptibilities of the audience change the tone of the speaker Hence patients are always agents to a certain extent, and the distinction between agent and patient is merely verbal

8. CESSANTE CAUSA CESSAT ET EFFECTUS—When the cause comes to an end the effect comes to an end How far is this saying true? Instances to the contrary are not quite exceptional Many effects continue long after their causes have ceased to exist Thus a man may take a cold bath in winter, shivering will continue long after he comes out of the water. A man is grievously hurt, the injury may continue long after the cause is removed Offensive words are addressed to some individual; the offence will continue and enmity subsist long after the utterance. Yet we might find instances in which the cause ceasing, the effect ceases Thus, a light bandage may cause pain, sometimes, the removal of the bandage will at once remove the pain Darkness in a room vanishes as soon as a lamp is brought and light again vanishes when the lamp is remo-

ved The cause ceasing, the effect also ceases in such cases. The difference between the two sets of cases is due to the fact that most things once produced continue as they are, whereas some things are instantaneous and require the permanent presence of the agencies which produced them at first *Cessante causâ cessat et effectus*, is, therefore, a statement which is true only in some cases

9 PLURALITY OF CAUSES —Many philosophers maintain the doctrine of "Plurality of Causes", namely, that the same effect may be due to many causes. Thus, they point out that motion may be due to many causes, death may follow stabbing, poisoning, diseases, &c, and so on However, if the whole effect (the concrete effect) is taken into consideration in these cases, it will be found that the doctrine of "Plurality of Causes" is not true * Motion may be produced by steam-force as well as by electric force Death may be produced by stabbing as well as by poisoning However, if we take account of the whole effect, we find that it is considerably modified accordingly as the cause is different. Electric motion and steam motion differ *concretely* as effects Death due to stabbing differs *concretely* from death due to poisoning. Just as the cause is a sum of conditions, so too is the effect a sum of co-effects, and hence there is nothing like a plurality of causes for the same effect The most scientific conception is that the same set of conditions is followed by the same set of effects, and that "the order of events is as uniform backwards as forwards" This is the final stage of the fully developed idea of causation (cp Venn's analysis). Evidently death due to disease is as an effect different from death due to a sword-cut or to an electric shock, and

* This is so in reciprocating causal relations

so on, for if the body is examined *post mortem*, the organism will be found differently affected The reason why we speak of a plurality of causes producing the same effect is that even as scientists we are interested in the *abstract* (or general) effect and hence do not take note of the whole of it Thus we are interested in noting that the functions of the bodily organism stop working Hence we look upon the effect death as the same in different cases If we have any medical or legal interest, we analyse the case fully and find the whole or concrete (specific) effect a different one in different cases

10 MECHANICAL AND CHEMICAL CAUSATION·—Sometimes two or more causes combine and produce an effect which is commensurable with the causes whereas sometimes this is not so Thus in Physics the former law holds good, in Chemistry the latter When a body is propelled in two directions e g, North and West, by two forces, it will move in the same direction as if first it had been drawn to the North and then to the West In Dynamics this principle is known as the Composition of Forces Analogically when two or more causes combine to produce an effect which follows the law of each cause separately and which is thus homogeneous to or commensurable with the causes we have what may be called the Composition of Causes, and causation of this kind is spoken of as *Mechanical Causation*. Thus if two men pull at the same rope in the same direction the effect is equal to the sum of the forces The part due to each cause may be traced in the effect, because the causes and the effect are homogeneous For this reason it is possible to *deduce* the effect from the causes in Mechanics Even when the forces thwart one another, the effect follows the laws of the causes and can be

computed as their difference Thus if two men pull at the same rope in opposite directions, the result depends upon the difference of their forces. The Law of the Composition of Causes is expressed by Bain thus: "When several motive powers are conjoned the composite effect is the sum or difference of the separate effects according as they conspire with or are opposed te each other."

As distinguished from this principle there is the principle obeyed by *Chemical Causation* There the cause and the effect differ, when combined the causes produce an effect which has different or heterogeneous properties altogether. Thus if Oxygen and Hydrogen combine water is produced, in the effect water the properties of the elements 'Oxygen' and 'Hydrogen' disappear Mill calls this class of cases "the heteropathic intermixture of effects" And simply because the intermixture is heteropathic, Chemistry is not a deductive science

Illustrations of the Composition of Forces are found in Physics, in Astronomy, in Physiology, and even in the Mental and Social sciences to a certain extent. The case of the Composition of Forces is the general one whereas that of Chemical causation is exceptional. The latter holds good in Chemistry, and all organic substances follow the rule of the heteropathic intermixture of effects. The Laws of Life are never deducible from a study of the laws of the ingredients of life

The distinction between the two cases of Causation shows that the analysis of nature is not an easy one but is very difficult in the case of chemical and organic phenomena. In face of such phenomena why should it be said that effects resemble their causes ? What resemblance can there be between bread and milk, and blood, nerves, and muscles ?

What resemblance is there between the tasting properties of the tongue, and gelatine, fibrin, and other products of the chemistry of digestion? So there is no resemblance between water the effect and Hydrogen and Oxygen the causes.

Note 1 ARISTOTLE'S DIVISION OF CAUSES --There are, according to the Aristotelian view four kinds of causes, the Efficient, the Material, the Formal, and the Final The Efficient Cause is the force which determines an effect, e g, the nerve-power and the instruments used in making a statue (an effect) The Material cause is the matter from which an effect is produced, e g, the stone out of which a statue (the effect in question) is prepared The Formal cause is the idea or the form of the effect which precedes its production, e g, the idea of the statue in the mind of the artist The Final cause is the purpose for which the effect is produced, e g, a statue being in memory of some great man, commemoration of his name will in that case be the Final cause of the same

Since science is concerned with Physical and Efficient causes, Inductive Logic is concerned with the same

Note 2 A HISTORICAL AND CRITICAL NOTE ON MILL'S THEORY OF CAUSATION --Mill's theory of Causation cannot be fully understood without making a reference to Hume's doctrines Previously to Hume the great majority of modern philosophers took it for granted that cause and effect were *necessarily* connected, and there was *power* or *necessity* in the cause to produce the effect Even so great a philosopher as Locke, who effected a revolution in modern philosophy by laying down the basis of Empiricism, did not reject the notion of *Power* or *necessary connection* in the relation of cause and effect He simply tried to show how this idea had come into existence The idea of Power according to Locke is a Simple Idea and has come to us empirically "Thus we say, fire has a power to melt gold, *i e*, to destroy the consistency of its sensible parts, and consequently its hardness, and make it fluid, and gold has a power to be melted, that the sun has a power to blanch wax, and wax a power to be blanched by the sun, whereby the yellowness is destroyed and whiteness made

to exist in its room In which and the like cases, the power we consider is in reference to the change of perceivable ideas For, we cannot observe any alteration to be made in, or operation upon anything but by the observable change of its sensible ideas, nor conceive any alteration to be made, but by conceiving a change of some of its ideas

Hume carried on the same vein of thought to such an extent that empiricism with him terminated in scepticism According to him causation depends on our expectation of certain successions and the relation of cause and effect is nothing but the succession of our impressions and ideas It is therefore subjective there is no objective order in causation For example, we see a flame and think that contact with it will burn our fingers We here expect that one perception will be followed by another As soon as we see a flame the feeling of heat is expected by us Causation is in *this* way identified with expectation that an effect will follow a cause is a matter of expectation and it is absurd to speak that there is any necessity power or objective connection between one event and another We see a certain order and expect it In nature there is no necessity no power because we never receive any impressions of the same and Hume cannot believe in the existence of anything which is not experienced or of which no impressions are received through one or other of the senses Particular cases of causation are thus easily explained away by Hume But how does he explain the truth of the Law of Universal Causation *i e* the theory that *every effect must have a cause?* To him there is no such '*must*' or necessity The idea of necessity and universality is based on all particular habits of expectation

If however, the idea of causation is *subjectively* determined how would Hume distinguish causal sequence from ordinary sequence? Getting warmth follows standing in the sunshine, and so too my seeing the ground-floor of a house may follow seeing the roof first In what lies the difference between these sequences? *Hume would say that the difference is created by "my habits of expectation"* Even if I do not myself go into the sunshine but simply imagine any other person going there, I should still "believe in" the ensuing of the heat In the other case, however, I will have no such idea When one sees a roof, no idea is presented to him of any other part of the

house As well may I see a table first and a chair next, or a chair first and a clock in may room next with no expectations whatsoever, The only difference, then, according to Hume between sequences causal and ordinary, lies in the fact that in the former we have certain feelings of expectation which do not arise in the latter The distinction of the two types of causation is not denied by him *He upholds the facts of ordinary consciousness, but comes to the conclusion that the basis for the same is entirely subjective* There is no power no mysterious tie, no necessity in the connection of cause and effect the necessity is not in the objects, but in us, the stronger our expectation, the more do we feel the necessity of the connection between a cause and an effect

The error committed by Hume was a very serious one *Expectation admits of degrees*, we speak of a higher and a lower degree of expectation Since his doctrine of causation is based on expectation, it would lead us to imagine that there must be *degrees in causation* as there are degrees in expectation Hume did not say so and could not also say so But this would be the logical consequence of his theory This however is simply *absurd* We never speak of one causation as more or less in degree as contrasted with another causation Moreover, if expectation is the only thing which enables us to decide whether a case is one of causation or not, what according to Hume would the sequence of day and night be ? *Our expectation of this sequence is the strongest possible Should we therefore regard day as the cause of night ?* On Hume s basis, we shall have to do this, yet, we know that day is not the cause of night It is a case of invariable sequence, but not of causation

The latter is the objection of Reid to Hume's doctrine of causation Prof Fowler tries to defend Hume in this connection by saying that though there are loose expressions in Hume's Essay in which the term cause is confounded with ' invariable antecedent yet Hume makes other statements according to which " Cause ' and " invariable antecedent" are not convertible terms, and day and night not the sequence of cause and effect (cp "Or, in other words, where if the first object had not been, the second never had existed " This cannot be said of day and night since the existence of night does not depend on that of day)

Nominally, modern scientists take their basis on the Humian doctrine of causation But while doing it, so many modifications are made in it that they can hardly be said to accept his theory *Hume's theory that the idea of causation depends on expectation, and is therefore subjective is universally rejected The idea that causation can only be established by repeated observation is also rejected For a scientist will be satisfied with a single experiment, from which, if it is successful he infers causation without the least doubt* One element of Hume's doctrine has however left a deep impress on philosophers of the empirical school and it is his idea that invariability of temporal sequence is of the essence of causation This idea is modified in a two-fold way by Brown it is modified by the doctrince that the invariable antecedent which is a cause must be also the *immediate* antecedent, and by Mill, it is said that it should be the *unconditional* antecedent When this is seen to be so, Reid's objection that the relation will even include the sequence of day and night, is nicely obviated

We have defined a cause as invariable immediate unconditional antecedent The unconditional antecedent must also be the immediate antecedent This is already pointed out some pages back *

The difference between Mill's view and Hume's will now be easily perceived Both began with sense-data and empiricism generally But whereas to Hume there was no certainty, but only probability (based on expectation) in regard to the relation of cause and effect to Mill, it was not so *Hume was a Sceptic, Mill was not Causation to Hume depends on subjective belief, to Mill, on objective certainty* So far as Mill's theory is concerned the sequence of causation is an objective one and our certainty in the matter is based on the sequence ' always " continuing, "always ' meaning "unconditionally as further explained in his analysis

Mill's analysis of causation is criticised from different points of view Mill defines a cause as an *antecedent* of a particular kind This raises the question, is *antecedence* in time of the essence of causation ? Is it true to speak of cause and effect as *before* and *after*, i e, as two *independent events*, the one preceding, the other succeeding ? Un-

* Mill's analysis of causation is in what follows taken as grasped

doubtedly in some cases of causation, we find that there is some event *before* and some event *after* and that therefore antecedence and sequence are predicable of them Thus, if a man takes poison, death ensues Here the taking of poison is prior, and the occurence of death is posterior in time Cause and effect are prior and posterior But Mill cautions us against this kind of attitude It is only the popular as contradistinguished from the scientific attitude Scientifically death is the result of the organic changes which *immediately* precede it, and *there are no two events before and after*, but rather there is *continuity of the cause in the effect* The cause is *not separate* from the effect the two are divided as it were by a mathematical line i e, a line without breadth they are two *aspects of a continuous process* Antecedence and sequence are *not thus essential aspects of causation* Mill's definition lends colour to it though as Mellone observes, "Whenever this is understood there is no objection to speaking of cause and effect in terms implying *duration in time*, for duration is an essential aspect of continuity"

Secondly, it is objected that a cause is not "a *sum* of conditions" positive as well as negative which invariably precede an event Mill's expression "some of conditions" would imply an arithmetical summing up of parts which may remain separate even when the summation is made In causation the parts or the conditions are absorbed in the whole and when this happens they no longer remain what they originally were Hence it is better to speak of a *totality of conditions* rather than sum of conditions

Thirdly, there are certain inconsistences in Mill's doctrine A cause is an "invariable anteeedent, and also an unconditional invariable antecedent But the doctrine of the plurality of causes is inconsitent with these two conceptions The doctrine of the plurality of causes says that the same effect may follow from many causes To speak of the cause as the invariable unconditional antecedent is misleading and inconsistent when this is borne In mind In fact Mill's final or third statement of the relation between cause and effect is evidently inconsistent with his doctrine of the Pluralityof causes Each definite set of conditions can produce "just one precise effect" and "no two different sets of conditions can produce precisely the same effect" If the sequence is *unconditional* each definite set

or totality of conditions will produce one precise effect only Thus, to take an illustration Motion is due to many causes e g, visible impact heat electricity, magnetic action gravitation, etc To the popular mind these are different causes but scientifically viewed there is only one condition common to them all e g, matter in motion All matter in motion is produced by other matter in motion This is the only antecedent of motion *it is the unconditional antecedent Scientifically, this is the only cause of motion*

Note 3 THE ORIGIN OF THE CONCEPT OF CAUSE --The *origin* of the concept of cause is, according to Hume, Mill, and other Empirical Philosophers, to be found in experience Certain successions are observed invariably and we distinguish them from others which are casual As against this, there is the doctrine of Kant and his followers, that the concept of cause is not derived from experience it is a priori and is presupposed in any experience of successive events It is a conception which is native to the mind it is not given by experience but is only occasioned by it

The notion of Power which attaches itself with reference to the connection of cause and effect is according to Hume simply a *gratuitous hypothesis* According to some the feeling of Power comes to us through our acts of Will Volition is efficient causation and in volition we are best conscious of power in ourselves Outward phenomena have the semblance of being produced by physical causes yet according to this school of thinkers the immediate agency even here is will, Divine Will External changes proceed from Divine Will just as internal changes proceed from Human Will As against this (Volitional Theory of causation) Mill urges that even a Volition is a physical cause and the power to will is not inherent in us but is only gained by experience

Note 4 THE EVIDENCE OF THE DOCTRINE OF UNIVERSAL CAUSATION --The doctrine of Universal Causation is that *Every event has a cause* What is the evidence which can support the truth of this statement With reference to the *origin* of the idea of cause, there were two Schools, the one which maintained that it is *a priori*, and the other which held that it is *a posteriori* or derived from experience If the idea is native to the mind, it carries its own truth with it Thus Dr Whewell says "We assert that every event must have a cause and this proposition we know to be true, not only probably, and

generally, and as far as we can see, but we cannot suppose it to be false in any single instance We are as certain of it as of the truths of arithmetic or geometry We cannot doubt that it must apply to all events past and future, in every part of the universe, just as truly as to those occurrences which we have ourselves observed *What* causes produce what effects, what is the cause of any particular event, what will be the effect of any peculiar process,—these are points on which experience may enlighten us Observation and experience may be requisite, to enable us to judge respecting such matters But that every event has *some* cause, Experience cannot prove any more than she can disprove She can add nothing to the evidence of the truth, however often she may exemplify it This doctrine, then, cannot have been acquired by her teaching "*

As against this sort of argument Mill and Bain carry on a vehement controversy and strongly uphold the empirical basis The idea that any denial of the doctrine of Universal causation is inconceivable is simply, according to Mill, a weakness of the human mind Mere belief is not proof, and it in no way dispenses with the necessity of proof Mankind have not always believed in the allied doctrine of Uniform Causation † For the Greek Philosophers recognised Chance and Spontaneity as ruling side by side with Order in the universe Even among Modern philosophers, there are many who uphold the doctrine that the human will is free and is not governed by a fixed law The belief in Universal Causation is not to be accepted on the ground that it is *a priori* and that its violation is inconceivable It is true according to Mill because it is itself an induction From the earliest times down to the present mankind have been seeing that the law holds good in particular cases, and there is no known instance of spontaneous origination of any phenomenon Hence the induction is arrived at Every event has a cause The Induction is Induction per Simple Enumeration This is criticised by Mill as a precarious type of Induction Yet, he accepts the validity of the law of Universal Causation on this very method How far is this allowable? The reply Mill gives to this question is that though Induction based on

* History of Scientific Ideas, Bk III ch ii I † This is the doctrine that the same cause is always attended with the same effect

uncontradicted experience is precarious, yet its precariousness is in a ratio which is inverse to the largeness of the generalisation The Induction in question is so wide and all-comprehending, that if there is anything like a violation of this rule, it must have come to our notice The generalisation, "Every event has a cause, is so widely diffused that there is no time, no place, no combination of circumstances in the world, but must afford an example either of its truth or of its falsity It is a generalisation co-extensive with all human experience, and since it is uncontradicted, it must be accepted as true, for if there is any exception to it, it must have been noticed, which however is not the case Even the exceptions which exist corroborate rather than contradict the rule Thus, the winds, waves, lightning, and other similar phenomena are pointed out as capricious But even in these cases, we find that in some of their manifestations these phenomena are obedient to the law of causation On this ground, Mill and Bain hold the law in question as established

As between the claims of the *a priori* proof and the empirical proof as thus expounded it is difficult to decide The constant sequence of one event on another may strictly speaking lead to the *strongest expectation* that the one is the occasion of the happening of the other Again how can our perception of sequences A, B C, D, E, F lead us to an interrogation of nature in order to explain an apparent irregularity in sequence X? If the mind is not prepared originally to start with certain principles, how can nature be interrogated and any event understood as connected with any other? Mere perception of succession never enables the mind to raise a question when a new event occurs, and ask the reason why and how it occured The mind in short, is not *passive* as the Empirical Philosophers think, it is *active* It has certain original or *a priori* forms of thinking as Kant and his followers say As Green puts it the idea of unconditional sequence between any two events arrived at in the way explained by Mill is simply "unwarranted There is no evidence *for* unconditional sequence, at best there is a high degree of probablity The Kantian School assumes the validity of certain fundamental beliefs, and the Empirical School assumes the validity of experience, without trying to explain how the very first experience could have originated Again, when Mill says that the wider an induction per simple enumeration

is, the safer it becomes, he commits a *petitio principii* For, why should this be so? It is so, because we have an *a priori* confidence that when the induction is very wide, it cannot be *casual but must be causal* we take it for granted, as our basis, that a *causal uniformity will continue* but if this is the process of thinking, is it not begging the question? The Empirical School has the merit of simplicity of analysis on its side, whereas the other School has the merit of starting with metaphysical presuppositions The solution of the difficulty cannot be arrived at without discussing the question How far is Empiricism metaphysically tenable? This, however, is beyond the scope of this elementary treatise

There is a third theory, which, while trying to explain the origin and evidence of universal beliefs, tries to combine the truths of both the above theories with certain modifications It says that universal beliefs are due to experience but the experience is not individual, it is the experience of the race transmitted by hereditary descent from generation to generation This is the evolutionary stand-point of Herbert Spencer and his followers This theory only partially solves the dificulty, for the question, how *ultimately* universal ideas are believed in, remains unsolved, and in order to solve it, we have to adopt one or other of the two theories noted above

NOTE 5 THE UNIFORMITY OF CAUSATION The Law of the Uniformity of Causation is that the same cause will produce the same effect If poison once causes death and at another time supports life it cannot be a cause of death at all By some men, the human will is supposed to form an exception to the Law of Uniform Causation, for it is free a man may act differently on two different occasions though the *motive* and the circumstances be the same Thus the desire to have money may move one to do an honest act to day, but tomorrow under the same circumstances, it may lead him to do a dishonest act The problem of the Freedom of the Will is itself a much debated question But it need not be touched here Whatever the decision of that problem may be, a student of Inductive Logic is not concerned with it Since scientific knowledge would be impossible if causation be not uniform, and since causation is uniform in all material changes, a student of Inductive Logic must accept the Law of Uniform Causation as very useful to him

But it should be noted that though the Law of Uniform Causation holds good, the converse of this law does not hold the same cause will produce the same effect, but the same effect has not the same cause, since there might be a plurality of causes

For scientific purposes, one may say that it is part of the conception of a cause that it should act in a uniform way But still this is not the *essence* of causation Though uniformity is an element which enables us to *recognise* causation, it is not an element *fundamental* in causation The *fundamental* element is the idea of *law* It is because there is a *law*, a *necessity*, an *unchangeable relation* between the *nature* of poison and of the human constitution, that death ensues, and ensues always, *i e* whenever poison is taken by man If the element of *uniformity* of sequence be regarded as fundamental in the causal relation, no event could have a cause unless it be repeated at least once, but this is absurd The causal character of a sequence is not derived from its uniformity, but its uniformity is derived from its causal character,

---

QUESTIONS

1. Examine the relation of Causation to the Uniformity of Nature
2 "In what relation does the antecedence and sequence of phenomena stand to the principle of Causation, and to the Uniformity of Nature"?
3 State and explain —
 1 The Law of Causation
 2, Tee Law of Universal Causation
 3 The Law of Uniform Causation
4 How far can you distinguish Uniformities of Co-existence from Uniformities of Causation?
5 How is cause defined by Mill? What improvements does he make in the popular conception of causation?
6 Would you prefer saying that a cause is a sum of positive and negative conditions, or a totality of such conditions? Discuss the question with illustrations
7 How do you account for the difference between the scientific and the popular analysis of a cause?

8 The Law of causation may be most correctly fromulated thus "Given that in any two instances the precise sum-total of antecedents recurs, so will the sum-total of immediate consequents, and conversely" Show that for the purposes of science this formulation will not be useful since it is never possible to get any two cases in which the precise sum-total of antecedents or the precise sum total of immediate consequents may recur

9 Is the sequence of day and night a causal one? If not, why not? Is it not an invariable sequence?

10 Show that a cause is an conditional immediate invariable antecedent Explain the necessity of each qualification of the word antecedent Show what is meant by saying that the cause is an 'antecedent'

11 How far is antecedence in time essential in causation? Would you accept that all causes are antecedent to their effect?

12 Is it proper to speak of cause and effect as agent and patient? If not, why not? Why is the mind generally not ready to regard a thing acted upon as a cause in the consequent result?

13 Bring out the chief points in Mill s theory of causation Show that Mill is inconsistent

14 What is the theory of Plurality of Causes? Mill maintains it Is it necessary?

15 Criticise Mill's theory of causation

16 Distinguish between mere sequence and causal sequence

17 How far is the cause contiguous with the effect?

18 *Cessante causa, cessat et effectus* Explain and discuss this statement

19 What according to Aristotle are the different kinds of cause?

20 How far is Mill's theory of causation an improvement on Hume's theory?

21 Explain and criticise the Humian analysis of causation

22 How do you account for the acceptance of the Law of Universal causation

23 Mill says "the precariousness of the method of simple enumeration is in an inverse ratio to the largeness of the generalisation' Explain this statement, and show how

accordingly the doctrine of Universal causation is found satisfactory.

24 Mill says "The uniformity in the succession of events, otherwise called the law of causation must be received not as a law of the universe, but of that portion of it only which is within the range of our means of sure observation with a reasonable degree of extension to adjacent cases Explain why this is so

25 Cause and effect are divided simply by a mathematical line" Explain what is meant by this statement

26 What is meant by the Composition of Causes? Distinguish between Mechanical and Chemical Causation

---

CHAPTER VI

PROCESSES SUBSIDIARY TO INDUCTION

I. Observation and Experiment

1. Analysis of facts —The process of finding out the phenomena which are the invariable antecedents of some other phenomena is dependent on an *analysis* of a given situation Thus if we want to find out the causes of the prevalence of cholera in any place, we must begin with an analysis of the situation We must analyse the climatic conditions into temperature, moisture purity of air, quality of water, and so on If a man loses his health all of a sudden in some new locality and we wish to find out the cause, we must analyse the circumstances, climate into temperature, purity of air, moisture, fluctuations of heat and cold, and so on the peculiarities of his mode of nourishment into quality and quantity of food, habits, state of mind, and so on The more thoroughgoing our analysis in these cases is, the more are we prepared to distinguish the essential from the non essential conditions. Having singled out the simple elements which go to form a

complex whole, our next step is to *find out the elements connected as cause and effect.* This requires us to look for *other instances where the groupings are different* Thus, if we are trying to find out the cause of cholera, we collect in our mind as many occasions and places of the occurrence of cholera as possible We find that fluctuations of climate are present in one place and absent in another, and yet cholera prevails in both places. This element, therefore, is not essential Similarly, in the other illustration, we find that the same individual had changed many places and had yet not suffered in health. This time, however, he went to a place which was over-populated, or it may be, his habits of life were owing to accidental circumstances greatly changed, and so on By analysing facts in this way, and *varying the circumstances* we are in a position to hit upon the antecedent connected with the given consequent The question, therefore, arises *How can we vary the circumstances ?* The varying of the circumstances is possible by more and more of *Observation* and still more by *Experiment*

2 OBSERVATON AND EXPERIMENT:—To observe is to *find* a fact to experiment is to *make* one In observation, we are passive, for we simply watch with attention phenomena as they occur, whereas in experiment we are active, for we put the phenomenon to be investigated under specially favourable conditions All experiments involve observation, but not *vice versa* Thus, if a man takes poison and dies, I may observe the symptoms of death If, however, a venomous serpent is caused to bite a goat, and the symptoms of the poison watched, we are said to experiment on the goat "When as in astronomy, we endeavour to ascertain causes by simply watching their effects, we

observe, when as in our laboratories, we interfere arbitrarily with the causes or circumstances of a phenomenon, we are said to *experiment*"

In all discoveries of causes and effects, experiment is more useful than observation. The following advantages can be claimed for it —

(1) In experimenting, *we can isolate the phenomenon* which is not so in observation

(2) Experiment allows *more of varying the circumstances.*

(3) In experimenting we can *reproduce* the *phenomenon at will*, whereas this is not possible in observation.

In the experimental sciences the phenomenon to be examined can be isolated In this way its analysis becomes simpler. Electricity cannot be examined in thunder-discharges But we can study it very easily by producing it at will in a room where it is isolated from modifying circumstances Similarly the study of a disease is best possible in a hospital, for there the sick people are wholly under the care of the doctor, and the disease is as it were isolated

In the experimental sciences we can vary the circumstances and try to see how one thing will react upon another under changed conditions In non-experimental sciences like Astronomy, however, we have simply to watch the motions, &c, of a planet under observation as they present themselves to us. We cannot change them at will Varying the circumstances is therefore an impossibility

The third point of superiority is of the essence of all experiments and is too obvious to be specially emphasised.

By experimenting we can produce a given result in the midst of known circumstances Experiment therefore is

more useful than observation if we want to go from a cause to its effect. If, however, we want to proceed backwards, observation is the only process that will avail us When we have nothing to guide us to the effect we have to start from the effect, for we are destitute of the source of experimenting We can by experiment produce effects from causes but not causes from effects In such cases observation is superior to experiment Thus to quote Mill: "We can take a cause and try what it will produce, but we cannot take an effect and try what it will be produced by We can only watch till we see it produced or are enabled to produce it by accident" Thus if a new disease makes its appearance in the country we have only to observe how it progresses and compare this with allied cases The conditions of diffusion can only be learned by observation Experiment is here evidently out of place

There is another point in which observation has an advantage over experiment From the very nature of facts, experimenting, even if possible, is not allowable in certain cases. Thus, if we want to study what effects will follow from a particular kind of poison, we cannot experiment it upon any human being We have only to wait for the requisite opportunity and then see what happens. We can observe what issue results from the intermarriage of a lunatic and an idiot, but it would be highly improper to experiment in this direction"

Observation and Experiment are in this way both useful We may have to find the cause of a given effect, or the effect of a given cause, observation helps us in the former task, experiment in the latter Since, however, experiment has decided advantages of its own, and observation is at a great disadvantage, sciences like Astronomy,

Physiology, Mental Philosophy, and Social Sciences which deal with phenomena in which experiments cannot be manipulated, are at a great disadvantage as contrasted with sciences like Physics and Chemistry. This accounts for the fact that Physiology, Mental Philosophy, and the Social Sciences are not in a more advanced state. The case of Astronomy is a unique one Its progress depends on the application of the Deductive Method This method is applicable in Astronomy, for the facts to be studied are simple; whereas in Physiology, Mental Philosophy, and the Social Sciences the facts are highly complex An animal is so complex an organism that its laws can never be predicted from a study of nerves, muscles, or bones In the Social Sciences, the same difficulty exists Yet, the statistics under our control being innumerable, approximate generalisations are easier in them than in Physiology.

3. RULES FOR THE RIGHT CONDUCT OF OBSERVATION AND EXPERIMENT:—There can be nothing like an art of observation Many people see and see not Many people see, but see wrongly. Many people see often, and then detect the material circumstances Whereas a few people are able to see the proper things at the very first time There are in this way all sorts of differences in the observations of men How men may be trained in observing correctly is a problem of education With that Logic is not concerned Logic can only lay down rules for the right conduct of Observation and Experiment. The following four rules should guide us in all Observation and Experiment.

Rule I. Observation and Experiment must be *Precise*

In order to arrive at precision, various instruments and methods have been devised Thus individual orga-

nisms may feel the same substance as either hot or cold, accordingly as they are themselves comparatively cold or hot. Our measurements of heat are therefore bound to vary, if they are carried on through the help of our sense of feeling. To obviate wrong observations, the thermometer *is contrived and with its help we know that bodily* heat can be correctly judged We will feel a body to be hot or cold incorrectly, but the instrument will never record a wrong fact To arrive at correct observations in Astronomy, we make use of the telescope and various other instruments The microscope, the rain-guage, the barometer, the clock, the balance, the galvanometer, the thermo-electric pile are all instruments through the assistance of which precision of observation and experiment is secured Again, different reults may be produced accordingly as different *qualities* of causes operate in bringing about an effect The truth of this is manifest in Chemistry In Medicine also certain doses when taken in larger quantities are productive of harmful consequences. Methods of precise calculation therefore, are absolutely necessary, and accordingly, we make use of fractions and decimals and so on.

Where single observations do not suffice, we try to arrive at precise results by an *average of observations* Thus, if we wish to find out the approximate rise and fall in the prices of food stuffs under certain conditions in a country, we take the prices at different similar times and find out the average of rise and fall If we wish to find out the average rainfall at a particular place, we extend our observations over a large number of years and determine it approximately Of course, average observations are liable to error, but they are less so than single obseievations, and

from the very nature of the case, they have to be resorted to frequently

Rule II Attend only to the *material* circumstances of the case under observation

Innumerable immaterial phenomena co exist with a phenomenon under investigation. Thus, if we want to find out the cause of a serious epidemic, it is needless to look to planetary changes, or divine wrath, and so on. Observation directed in that direction is immaterial So, some people in ancient times believed in omens and when they started for war looked for auspicious omens The result success or defect, however, can hardly be said to depend on certain birds considered as auspicious Before, however, rejecting any antecedent as immaterial, we should make sure that it is so, otherwise the first rule will be violated, for we then lack in precision, we omit to take account of one of the items under consideration

Rule III *Vary the circumstances as much as possible*

If a disease has to be studied, we should observe its effects on persons of different sexes, ages, habits, climates, and so on. If we want to study the cause of an astronomical phenomenon like an eclipse, we should observe different eclipses of the sun and the moon Then and then only are accidental circumstances in our observations eliminated

Rule IV As far as possible *isolate the phenomenon* under investigation.

Thus, if we wish to observe the phenomenon of magnetism we should isolate it A wooden house should be constructed and magnetism then studied, for then only are local disturbances of pieces of iron prevented If we

want to study lunacy, it can be best studied in a Lunatic Asylum where there are no circumstances which excite the minds of lunatics If we want to sudy the effect of a particular drug, we should take it alone, i e, not with other drugs which may enhance or hinder its working. Prof Fowler gives a beautiful illustration of the isolation of a phenomenon. When there is a total eclipse of the sun, the moon totally covers the sun's surface. Then certain rose-coloured projections are seen proceeding from the dark surface of the moon They are really projections from the sun The sun being eclipsed, they are isolated and observed These red projections or " red flames" are now known to be portions of an atmosphere of incandescent hydrogen enveloping the sun Their existence could never have been observed had they not thus been isolated. Here there is as it were an experiment performed by Nature (the total eclipse), and the phenomenon consequently discovered

At times, it is not possible to isolate the phenomenon under study Thus, if we wish to study the effect of a particular tonic on the human organism, a difficulty of the kind comtemplated presents itself to us. For the effects of moods climate, and particular diets are bound to intermix with the effects of the medicine in question The most that we can do in such a case is to diminish the action of such concomitant circumstances as far as possible, and then perform the experiment

The four rules above-mentioned are chiefly useful in experiments rather than in observations, for the former are under our control, whereas the latter, for the most part, are not

II CLASSIFICATION: NOMENCLATURE: TERMINOLOGY

4 CLASSIFICATION, MEANING· We are classifying things at every stage where we use general names. When we use the word "man," we hit upon certain resemblances; the beings who possess them are "men" and those who do not are "not men" We classify beings accordingly as they have or have not certain physical and mental peculiarities. So of other names like "metal," "element," "plant," "fish," &c, &c, Every name connoting an attribute divides by that very fact, all things into two classes, namely, things possessing it, and things not possessing it Hence it is that Jevons says, "Every law of nature which we arrive at enables us to classify together a number of facts, and it would hardly be too much to define logic as the *theory of classification*," since in reasoning, it may be urged we affirm of a part what was previously affirmed of a whole class

Jevons notes in this connection the derivation of the word "class." There was a peculiar practice in ancient Rome All the people in the state were summoned together at certain periods. This ceremony was known as *clāsis*, from Greek *clāses*, derived from *kaleo* which meant to call together. A class thus meant an *order* of people Servius Tullius divided the people into six orders according to the amount of tribute they could pay. By degrees the word came to stand for "any organised body of people," e g, an army, a fleet of vessels as marshalled in a fixed order, and finally, by analogy, any collection of objects carefully arranged This last is the meaning which is useful to us, though when we speak of the classes of people we curiously follow the etymological sense of the word

Classification is thus arrangement It may be defined as *an arrangement of things according to their resemblances*

5. HOW DOES THE SUBJECT OF CLASSIFICATION FALL WITHIN INDUCTIVE LOGIC?— The subject of Logical Division and Sub Division falls within the scope of Deductive Logic Division and Classification are interrelated Classification means division and sub-division In Division, we however start from a *given* class, and divide it into its sub-classes. We break up a whole, e g, books, into its parts logically, e g, into those written in English and those not written in English (Dichotomy) In Classification we arrange certain things and then arrive at a Division and Sub-Division, i e, form classes for the sake of studying the various properties of objects falling within the same class Thus in Classification we systematically arrange animals, plants, minerals, &c, for the scientific purpose of studying their form, structure, and function. Division and Classification perform the same task Yet it is the practice of some logicians to treat "Division", in Deductive Logic, and "Classification" in Inductive Logic The reason why "Classification is treated in Inductive Logic is that it is a process which is subsidiary to the act of generalisation or Induction Classification facilitates the study of groups of attributes in such a way that inductions of causation or co-existence may be easily traced We are more likely to find out general truths in connection with the Vertebrate animals after having classified animals into Vertebrates and Invertebrates and then trying to see how the attributes which co-inhere in Vertebrates could have come into existence rather than otherwise Thus Fowler says "Before proceeding to the attempt to ascertain inductively facts of co-existence or causation amongst a vast mass of phenomena it is often highly important

* Elementary Lessons in Logic, p 227

if not essential to arrange these phenomena in groups, as well as to determine the order in which these groups shall be arranged "* (Inductive Logic p. 53).

In short, resemblance of things in groups of qualities or attributes being the basis of classification, this process is subsidiary to Induction inasmuch as, and in so far as the discoveries of inductions of co-existence and causation are facilitated by it

The same point may be otherwise borne out by observing that in Classification we may either proceed deductively or inductively Just as in proving propositions we may proceed from the more to the less general or *vice versa*, i e, deductively or inductively, so in the formation of classes we may begin with a larger class and break it up into smaller ones, or beginning with smaller classes group to large ones, in the former case, our classification is deductive, in the latter, it is inductive. Deductive classification is better spoken of as Logical Division Just as Deduction and Induction are interrelated, so too are these processes interrelated Thus we may begin deductively from Animals and go down to Vertebrates and Invertebrates, or inductively from dogs, cats horses, monkeys, and go up to the Mammals, and then taking

* Accordingly Fowler's definition of a Scientific Classification shows directly that it is subsidiary to Induction "A scientific Classification regarded as subsidiary to Induction employed for scientific purposes may be defined as "*A Series of Divisions so arranged as best to facilitate the complete and separate study of the several groups which are the results of the divisions as well* as *of the entire subject under investigation*," Compare Mill's statement "The general problem of classification in reference to these, namely scientific purposes may be stated as follows To provide that things shall be thought of in such an order as will best conduce to the remembrance and to the ascertainment of their laws 'System of Logic," p 406

Mammals, Amphibia, and so on go up to Vertebrates. But the upward and the downward processes are based on the same principle—associating or keeping together like things. Though the two processes are thus dependent on the same basis, yet it is evident that for Inductive Logic Inductive Classification is important For in Inductive Classification we begin from less general classes like horses, cats, dogs, monkeys, and then go to a more general class, Mammal In this way the points of resemblance and difference between the different sub-classes are better analysed, and inductions of co-existences and causation are more conveniently established than if we had begun from a larger class and gone down to smaller ones. In the latter process the examination of the natures of the sub-classes is not forced upon us · we simply begin with the one point of resemblance deductively, and further analysis is stopped.

6 Conditions of Goodness in a Classification — In classifying objects we collect together things which resemble one another But it is not any and every sort of resemblance which should be taken into consideration For I might as well collect chalk, white paper, milk, a with piece of cloth, and speak of them as white substances They have *whiteness*, *materiality*, and *utility to man* as common qualities If anything which has common qualities is to be regarded as a class, this collection would be a class But we never make such collections The reason is that the common qualities here are not material They are not qualities which may enable us to pass from them to the other qualities of the objects concerned They are not what may be spoken of as "*essential*" qualities Take, however, a classification of books into philosophical, poetical, histori-

cal books, novels, &c It is superior to other collections, and is a collection which we naturally make, because the quality of being a book runs through all the collections in common It is an essential quality because it enables us to determine the good many other qualities of the sub-classes.

The conditions of goodness in a classification are following:—

(1) A classification is good if it *enables the greatest number of general assertions to be made about the class.*

A dictionary is a classification of the words in a language arranged alphabetically. The index of a book is also a classification of the contents in an alphabetical order. From the fact, however, that there are certain words in a dictionary or in an index on a particular page, we cannot make any assertion in common about them. Here we have classifications which are very useful to us and very convenient for reference, yet they do not allow us to make any general assertions Take, however, a classification of Vertebrates into Mammals, Birds, Reptiles, Amphibia, Fishes, and it will be clear that from a mere knowledge that a creature is a Mammal a large number of general assertions can be made about it. Thus the following description of a Mammal will be found to contain a collection of many general assertions.—

"Organs of lactation Hot blood. Circulation complete, and heart with four cavities. Pulmonary respiration simple Lobes of the cerebellum reunited by an annular protuberance Lower jaw articulated directly with the cranium. The body generally covered with hairs. Viviparous."*

* Milne Edwards' *Zoologic*, quoted by Flower in his "Inductive Logic,' p 68

From a mere knowledge that men and monkey are mammals we are in a position to assert many zoological generalisations about them that they have warm blood, have hair, have a particular kind of head, &c, &c, and that they can have nothing in common with the vertebrates like fishes (having cold blood) which are some of them not-mammals What assertions, contrasted with this, can be made of the words on a particular page of a dictionary? We can only say that they begin with a particular letter 'A,' or 'B,' or 'C,' or whatever it may be But there is nothing in common as between the various words, historical, botanical, poetical, and so on, which may occur on the same page

(2) A classification is good if *it enables us to infer of any other member* of the *same class a great part of what we know of one member.*

Thus in the Zoological classification above noted, from a knowledge of the attributes of a monkey we may pass on to a knowledge of good many of the attributes of a man Both man and monkey are mammals and hence there are good many resemblances between the two From a knowledge of the one we can pass on to a knowledge of the other to a great extent This is impossible in the other classification Or suppose we classify men into those who are six feet high and broad- chested, and those who are lacking in these qualities For military service these are qualifications and the classification is convenient But we cannot pass from the nature of one soldier to that of another, from a simple knowledge of height, and breadth of chest to a knowledge of character

(3) A Classification is good if we have the *greatest number of points of mutual resemblance*, and the fewest number of points of resemblance to members of other groups.

Man has the greatest number of points of resemblance with monkey (we have noted them already), and the fewest number of points of resemblance with reptile or fish. The only point of resemblance between a fish and a man is in the fact that both are Vertebrates, but otherwise there are many diversities in physical structure and function. In the classification of men into those who are 6 feet high and those who are not, the only point of resemblance in the members of the first class is in their height. In character, race, habits, and modes of life there may be all sorts of difference possible. Moreover, the man who is 6 feet high may resemble the man who is less than 6 feet high in being poetic, Indian, noble, patriotic, and so on

A classification which satisfies all these conditions, in brief a classification which groups together objects which have *essential* points of resemblance (meaning by essential inductively or materially essential points of resemblance), is *a natural classifiction,* and one that does not satisfy them is an *artificial classification* The former kind of classification is also called *classification by series* It is illustrated in the sciences of Zoology, Botany, Mineralogy, Crystallography, &c The other kind of classification may be illustrated by any sort of arrangement which is founded on a single basis It is generally resorted to for purposes of convenience Thus, we have an artificial classification in the following cases.

(1) A classification of books according to the alphabetical order, or according to size, or according to language

(2) A classification of population according to place of birth, or language uttered, or age, or sex. An artificial classification serves the immediate purpose, and for that end is very convenient Hence the same thing may be differently

classified accordingly as our purposes vary Thus the statist would classify population according to age, according to condition, married, unmarried, widowed, according to education, to state of body, and so on The lawyer will classify it according to his purpose, thus if he is treating of personal law in India, he would speak of Hindus, Mahomedans, Parsis, converts to Christianity, and so on

(3) A classification of plants according to their size as herbs, shrubs, trees, or the country from which they are derived, and so on An artificial system of classification in Botany is the one that is known as the Linnæan Linnæus classified plants according to the number of stamens and pistils in them, *i e*, according to the number of the male and female organs found in the flowers of the plants. This system is very convenient for purposes of distinction, and the distinctions are easy to grasp on this basis The system is not natural, for it is not based on a discovery of *affinities or resemblances of properties in the plants*

From the above examples it is clear that in artificial classification the basis is very often a *single attribute*, and the classification has a special purpose to serve Natural classification is not appropriate for all purposes, not even in science, for when we merely want to detect the name of a plant, metal, or animal, natural classification will not help us If we merely want to detect what animal a particular specimen is the knowledge of zoological classification will not help us much, on the contrary, we then start from outward or visible points of recognition So in Botany also, natural classification rests on a minute examination of the seed, arrangement of seed—vessel, and so on. These are things sometimes impossible to recognise.

Hence the necessity of an artificial classification (based often on the ground of a single characteristic).*

7. Natural classification and Division by Dichotomy.—Division by Dichotomy is the formal division of a class by the principle of excluded middle The process of division is here simple and also exhaustive. But it labours under a radical weakness as contrasted with natural classification If a class A is to be divided, it would by dichotomy be divided into B and not-B, not-B into C and not- C and so on Land would be divided into Building Land and Not-Building Land, the latter into Farm Land and not-Farm Land and so on. The division here works with negative notions Now a negative concept can give no clue to further development. For example to farm Land is not a kind of not building Land: not to build gives no positive notion at all A natural classification is in this respect better than a division by dichotomy. Thus if we divide vertebrate Animals into Mammls, Bird, Batrchia, Reptiles, and Fishes we show these species as alternative developments of a common class-notion. A formal division can never show how its sub classes are developments of the class notion with which we start; a natural classification can show this most effectively, and therein it is scientifically useful whereas the formal division has only a formal utility

8. TERMS IN CONNECTION WITH CLASSIFICATION,—Genus and species are larger and smaller classes Thus a mammal is a genus and man is a species. But the same

* The method determining by means of a single attribute the position of a natural object in a classification is known as Diagnosis or Characteristic

class which is a genus may become a species with reference to a larger group of individuals Mammal would be a species of Vertebrate animals This is the way in which the terms are used in Deductive Logic But in the inductive classifications in Botany and Zoology, the terms are differently used By species is there understood the lowest class in a scale of classification, and by genus the classes one step above that Thus, Lion, Tiger, Leopard, &c would be the species in the natural classification of the animal world, and Felidæ, Hyænas, and such other classes would be spoken of as "genera" Then we have terms like Tribe or Family, Order, Division, Class, and Kingdom in general use and in rising scale. No further division of species will give us a new division of a natural kind It can only give us a different variety of the same Thus, as Lions, African Lions do not differ from Syrian Lions The two are not different natural kinds The differences between the two lions are not regarded as specific, and then their classes are designated as *varieties*,

9. NOMENCLATURE AND TERMINOLOGY:—Closely connected with the question of classification is the question of Nomenclature and Terminology A classification is mainly useful in two ways It is useful for the better understanding of nature Secondly, it is useful for helping the memory. When attributes in their co-existences and sequences are noted in the form of a classification, they require to be remembered Classification itself helps memory For we remember things on the basis of certain associations, and similarity is a principle of association The object of classification can only then be said to be fully achieved when the Nomenclature aids our memory. What is Nomenclature? What is Terminology? What are the essentials of a good

bed. Thus, while describing an animal we may speak of its physical parts, e. g head, heart, nerve, muscle, tendon, vertebra, &c: while describing a plant, we may speak of its stalk, leaf, corolla, stamen, pistil, and so on Secondly, there should be a distinct and separate name for every metaphysical part or quality of an object Thus, we speak of the colour, weight, extension, figure, solidity, &c. of chalk, or roughness, smoothness, fragility, specific gravity, &c, of gold, and so on Thirdly, we need names for the processes and dynamic aspects of objects in general Thus we speak of affinity, causation, gravitation, refraction, respiration, association, and so on

A good terminology is the basis of a good Nomenclature The latter is dependent on the former. As Whewell puts it in Botany "the recognition of the kinds of plants must depend upon the exact comparison of their resemblances and differences and to become a part of permanent science, this comparison must be recorded in words"

Classifiction, and closely connected with it, Nomenclature and Terminology are thus seen to be processes subsidiary to Induction We have examined these processes as so concerned and in the outline A deeper study of this subject, involves a special knowledge of particular sciences, especially Botany, Zoology, and Mineralogy In fact Inductive Logic derives the formal rules of testing classifications from an analysis of the various classifications on these sciences

---

Not CLASSIFICATION BY TYPE AND BY CHARACTERS–By a type is to be understood any instance which eminently possesses the character of the class According to Whewell we should proceed in a classification by *type* or by resemblance to eminent instances of a

class and not by *definition* or by character. Thus, according to him the class mammal would be determined by resemblance to a typical species of that genus (e.g., a dog, a monkey), and not by an enumeration of characters. This according to Mill is not so. Mill was right in so holding, for if we determine a class by a type our classes will be arbitrary. This is not so in nature. For there are real distinctions in nature, one species being determined by innumerable characters *closely connected with one another*, which may have nothing to do with another species.

III. HYPOTHESIS

1. **What is a Hypothesis? How is it subsidiary to Induction?**—Etymologically the word Hypothesis means putting under or supposition. It means mentally putting something under something else which is to be explained. In Science it means imagining some thing, force, or cause as the basis underlying some phenomenon. By an irresistible impulse the mind tries to explain away facts of observation, and in order to do this, in order to establish the mode of co-existence or causation of phenomena observed, a *hypothesis* is framed, which when found established becomes a *theory* or *a fact*.

The formation of a hypothesis is therefore *a stage of explanation*. Let us take any fact to be explained and analyse what a hypothesis means. Suppose an individual X is found dead in a lonely place. There is a knife by his side and blood on his throat and clothes. Here is a fact for explanation. If another individual A was seen murdering X, no hypothesis has to be framed. But if there is no such sufficient evidence, some supposition has to be made. Was it that X committed suicide, or that he was murdered? Suppose, further, that X is identified to be a very poor man and it is found that he was in

very straitened circumstances, that he complained about his poverty to his friends some time back, that he had to spend a large sum of money after the marriage of a certain relation of his, that for this purpose a large debt had to be incurred, and that he had no means for paying off the same. These are all facts which may raise a presumption that life was burdensome to him. But after all this is insufficient evidence. Life is burdensome to many people, and that, from more points of view than one. They do not, therefore commit suicide. Suppose further that on the ground where his dead body lay, there were marks of struggle. This circumstance goes against the assumption of suicide. Suppose further that the knife by his side bears some marks from which an individual B says that it belongs to Y. Did Y then commit the murder? Was it murder and was it committed by Y? This is another hypothesis. Suppose that it is proved that the death took place at 6 P. M. on August 12, 1910. But it may be proved that Y was at that very time engaged in his usual professional work at a place far away from the one where the death took place. Y might repudiate the charge of murder very easily by proving *alibi*. But suppose further that the proof that Y was engaged in his usual work, depends only on a certain entry of presence in an office-book which is always in Y's possession. It may be that Y may have made a false entry. This is another hypothesis still. Not to proceed further, and to analyse what we have already said, it will be noticed that there are many suppositions here to explain the death of X. There is the supposition of suicide, that of murder, murder by Y, impossibility of it on the ground of *alibi*, possibility on the ground of a false entry. They are all based on insufficient evidence. Certain facts are known to be real, namely, the signs of struggle, the burdensome life of X, the identifi-

cation of the knife, and the entry We try to harmonise the assumptions with these facts If all the facts are consistently harmonised with a particular assumption, that assumption or hypothesis would be deemed correct

But at times there is no evidence forthcoming and we have to try to explain away a fact. Suppose in the case of X's death, there is no knife near his dead body, and no sign of struggle near the place of death To explain death in such a case an investigating officer will have first to grope in the dark He will have to guess how the death could have occurred Was it suicide or murder? This is the question which he will have first to decide If suicide, what possibly could have been the cause, if murder, who possibly could have been the murderer ? Evidence has to be searched in such a case from the beginning.

Thus, while making suppositions we start with either insufficient evidence or no evidence. Just as we make guesses in practical life, so too do we in the solutions of scientific problems *The technical names for suppositions made in this way in order to arrive at the scientific explanations of things is Hypothesis*[1] Mill defines an Hypothesis as "any supposition which we make (either without actual evidence, or on evidence avowedly insufficient) in order to endeavour to deduce from it conclusions in accordance with facts which are known to be real under the idea that if the conclusions to which the hypothesis leads are known truths the hypothesis itself either must be or at least is likely to be true" This definition is applicable to

1 A Hypothesis may be defined as an imagination with a view to scientific explanation

a *legitimate* scientific hypothesis but it should be noticed that not all scientific hypotheses are legitimate.

We do not always hit at the right laws of co-existence and causation. Very often we have to discuss between two or more rival hypotheses in order to establish a valid induction Thus to take ordinary illustrations from practicular circumstances Is it with future expectations or quite disinterestedly that a friend helps us in a difficult situation? These and such other problems are quite ordinary in life Their aim is to explain certain facts, to show how they were *caused* and the rival hypotheses were *subsidiary to them* So in science we have rival theories, or better, hypotheses to explain any fact Thus to explain *solar heat there are the two hypotheses (1) the Meteoric* Theory, and (2) The Theory of chemical combustion The first hypothesis asserts that the sun's heat is due to the fall of asteroids, whereas the second asserts that it is due to certain chemical processes in the substance of the sun So before the Copernican theory was established, there was the Ptolemaic theory conflicting with it.

11 SUBJECTS OF HYPOTHESES —There are three subjects or things concerning which hypotheses may be framed Firstly, a hypothesis may be made concerning an *agent* explaining a phenomenon Thus the received or current explanation of the Bubonic Plague involves an agent, namely, certain bacteria The discovery of the planet Neptune was first preceded by the hypothesis that something which could account for the perturbations in the movements of Uranus ought to exist This was the planet Neptune Its existence accounted for the perturbations. Secondly, a hypothesis is made concerning an agent's *operation.* The undulatory hypotheses of Light involves the *agency* of

ether, and the law of its *operation* which is supposed to be in the form of waves Thus, light according to this hypothesis would travel through waves or rapid vibrations of the supposed agent The agent however may be known and its operation alone may be hypothetically conceived. Thus, so far as the motions of the heavenly bodies are to be explained the agents on which they depend were known, namely, the Sun, Moon, Earth and the different falling bodies and plants. No outside or other agents intervened Their motions were attempted to be explained by the now accepted theory that they were due to mutual attraction with a force proportional directly to the product of their masses and inversely to the squares of the distances between them. Thirdly, a hypothesis may be made concerning a *collocation* or a group of objects Thus, the Ptolemaic theory was a hypothesis which tried to explain the plan of the solar system. The rival theory was the Copernican one. Whereas the first asserted that the earth was in the centre, the second asserted that the sun was

12 ESSENTIALS OF A GOOD HYPOTHESIS.—The characteristic of a genuinely scientific hypothesis is that it is bound sooner or later to be converted into an established theory, that it is not destined always to remain an hypothesis. Hence it must admit of being either proved or disproved. If it is of such a nature that it can neither be proved nor disproved, it is not a scientific hypothesis at all The *first* essential of a good hypothesis is that it *should admit of verification or disproof* The proof or disproof may not be at once forthcoming But at any rate if there is no likelihood of the hypothesis being by subsequent investigation either proved or disproved, it should be rejected. The oriental theory that the earth is suspended in space

and there supported on the *Shesha Nâga* (serpent) gives us an agent for the support of the earth It cannot be proved, nor can it be disproved, since a divine creature with divine powers is imagined For this reason the hypothesis is to be rejected as unscientific The westerners in ancient times imagined that the fires of Mt Aetna were due to the gaint Tiphœus being chained beneath it. The hypothesis admits of neither proof nor disproof The ordinary prognostigations made by astrologers are of this very nature Some influences are imagined to exist If certain things are done under certain planetary conditions, certain results may be expected If they do not follow, the astrologer would assert that certain other planetary conditions were not taken into consideration, and surely no one can take all the conditions into consideration. The assumptions, therefore, *evade proof or disproof* Hence, ordinarily they are worthless The sociological hypothesis that the formation of a state is due to a contract is of this nature The hypothesis can neither be verified nor disproved, since it takes us to prehistoric times

There may be certain theories which are not likely ever to be positively proved or disproved They need not, therefore, be rejected as unscientific For it will suffice, if they are such as are in the long run likely to be more or less probable The meteoric theory of the solar heat is of this kind It asserts that in the fall of comets and asteroids we have an agency which can account for the solar light and heat. It is a hypothesis which cannot be strictly speaking proved or disproved Yet, it may be seen to be more or less probable For its basis is that there are innumerable comets and asteroids, and that many of these innumerable comets and asteroids are owing to the force of

gravity attracted by the sun and other planets. Further, the theory asserts that there is a resisting medium in the universe, through the friction of which all the masses in the solar universe are being attracted towards the sun. The conjecture, therefore, is natural that the innumerable comets and asteroids in this way drawn towards the sun, produce heat and asteroids in an enormous quantity in the act of mechanical collision which evidently is bound to take place with great force. The lost energy of the sun is in this way more than replaced on the assumption made This theory is bound to be made more or less probable by the progress of astronomical observations It cannot be directly proved or disproved. But a progress in the knowledge of meteors, asteroid and the resisting medium if any, is sure to make the theory more or less probable The data required to make the hypothesis more probable are a knowledge that there is a large number of meteors circulating round the sun and that they are in so large a number as would suffice to produce the solar heat in question. The theory of Evolution cannot similarly be strictly proved or disproved. For after all many missing links in nature have to be supplied by the imagination if the theory is to be accepted. But the discoveries of the fossils of unheard of animals very often bear testimony to the truth of the theory. Hence it is being made more and more probable as a hypothesis.

The expression *capable of being proved or disproved* is rather vague and needs an analysis. A hypothesis is capable of being proved if it can be (1) distinctly and consistently *conceived*, (2) and is *verifiable by facts*. Thus if a fact is to be explained and two inconsistent theories can be as distinctly perceived to be true there must be something wrong

to start with. The hypothesis must be such as can be verified by facts If it is a new agent that is conceived we should be able to directly observe it If direct observation is impossible, there should be some evidence of its existence *independently* of the facts invented This is what is meant by saying that the hypothetical cause or law must be a *vera causa*. Thus if it is conceived that bacteria are the cause of a certain disease the proof may be successfully based on direct perception But various agents which cannot be perceived are conceived in science and the conception may be regarded as a legitimate one if it can be independently supported and thus conceived after the analogy of experience. Thus the presence of a luminiferous ether cannot be established by direct perception Yet it may be supported on an independent basis Such a basis is afforded by the observation on the history of Encke's comet The career of this comet was retarded and it was seen returning sooner than calculated This fact supports the theory of ether, for it might be supposed that this agent resists the comet and reduces the extent of its orbit whereby the comet returns sooner. The ether cannot be perceived yet the hypothesis is tenable though not established, for the ether is a *vera causa* i e, an agent whose existence is provable independently of the hypothesis

A second condition of a scientific hypothesis is that it *must not conflict with facts already observed or with the inferences deducible from them* This rule agrees with the preceding, that a hypothesis must admit of verification or disproof In fact it may be regarded as a negative condition of the acceptance of the first rule Every hypothesis must agree entirely with the facts which it was invented to explain. This is what is meant by saying that it should be consis-

tent and distinctly conceivable. But further, a good hypothesis must agree with a wider range of facts. It should be such that it can have a place in the already established truths of science It should not be inconsistent with the general body of experience Thus at the present day to maintain that an eclipse of the moon is due to the action of *Râhu* would be absurd, and the hypothesis has to be rejected because it implies an astronomical agency which is inconsistent with the established astronomical truths, for we know that no agencies beyond the masses of matter in space and their laws determine the working of the different astronomical phenomena. To assert that the heavenly bodies move in perfect circles as the ancient people imagined, is also an assertion of this type, for it disagrees with the accepted theory of elliptical motion

In connection with this point it might be noted that according to Whewell a strong mark of the validity of a hypothesis is that there may be with reference to it a "*Consilience of Inductions*" This means that the hypothesis agrees with *distinct inductions respecting different classes of facts.* In short, this is the same thing as saying that a hypothesis should agree with known and established truths. The laws of comets, stars, tides, the satellites, and the motion of the Earth were all consistently explicable by the theory of Gravitation. The Law of Gravitation could account for all the observations mentioned. There was a Consilience of Inductions and hence the Theory of Gravitation was remarkably found true.

Thirdly, the hypothesis must be *adequate* to account for the facts in question If it is a cause that is imagined, its presence must account for the occurrence of the effect.

If the effect is incongruous with, or out of proportion with the cause, the hypothesis should be rejected. Thus, if two persons were found in a lonely place and one subsequently found murdered when the other absconded, a question arises how the murder occurred. Is it the other person who was the murderer? The persons were seen abusing one another some time back and it may be that through excitement the one may have murdered the other. The hypothesis is evidently inadequate to explain the result death. For mere abuse is never so adequate a cause as to terminate in such an effect. But suppose, further, that the other or accused person was very excitable and too violent in his dealings even with ordinary persons under ordinary circumstances. With this knowledge, the same cause becomes now adequate, and the charge brought against the second individual may be tenable as a hypothesis. We very often criticise people, impute motives to them, and fret with imaginary wrongs. Our friends correct us by suggesting the question, how far even if the causes exist, they are *adequate* to produce the effect. One of the most familiar instances of an *inadequate hypothesis* is the theory started by Voltaire, there is little doubt in irony, that the marine shells found on the tops of mountains are Eastern species, dropped from the hats of pilgrims as they returned from the Holy Land. Such a theory would obviously be inadequate to account (1) for the numbers of the shells, (2) for the fact that they are found imbedded in the rocks, (3) for their existence far away from the tracks of pilgrims, to say nothing of the fact that many of these shells bear no resemblance to recent Eastern species, while none resemble them exactly."*

* (Fowler, Inductive Logic, pp. 105 6)

In connection with this point it may be added that if a hypothesis which was intended to account for a whole phenomenon is inadequate for that purpose but yet partially explains it, it should be accepted as scientific A hypothesis is not to be totally rejected if it is inadequate to explain all the phenomena in question Thus a charitable donation may not be explicable in a particular case on the theory of love of fame, yet the latter may have partially operated as a motive together with other motives like charitable disposition, or fulfilling promises previously made, and so on.

Fourthly, a hypothesis if it is of any genuine utility, *must reconcile at least two facts* If we were to explain the effects of opium by saying that it is soporific, we have not traced out any cause at all, for the evident reason that we have not attemped to reconcile *two* facts If, however, we can test the botanical properties of opium and the conditions between the two, we may get a hypothesis which may be regarded as having a scientific value This point is too obvious, for in all inductions and problems connected with them, we are concerned with real and not with verbal propositions

To sum up, the conditions of a good hypothesis are as under·—

(1) The hypothesis must *admit* of *proof or disproof* At any rate it must admit of being rendered more or less probable by subsequent investigation

(2) It *must not conflict with* facts observed, or deduced from such facts

(3) It must be *adequate* to account for the facts in question

(4) It must *reconcile at least two facts.*

(13). THE PROOF OF A HYPOTHESIS VERIFICATION AND PROOF.—To verify a hypothesis means to deduce consequences from it and show that they are true To prove a hypothesis, something more is necessary, namely, to show that the consequences would not follow from any other hypothesis Unless it is shown that no other hypothesis will explain the facts, mere verification will not do verification is not completed proof. Suppose A is charged with theft and the stolen article is found in his house Here there is verification If theft is committed the stolen article will be in A's house But evidently this is not the proof of A's guilt, unless it is shown that the article will not be in the house on any other supposition. To lose sight of such a piece of reasoning would be to commit the fallacy of affirming the consequent. If A is, B is: If the hypothesis is true the explanation is forthcoming But does it follow that if B is, A is? It may or may not be No hypothesis can be, therefore, said to be proved unless it is shown that it is the *only* hypothesis which would explain the facts.

(14) PREDICTION AS A MARK OF A TRUE HYPOTHESIS:—According to Whewell prediction is a mark of the truth of a hypothesis If we can through the help of a hypothesis predict certain phenomena precisely and the prediction is afterwards found to be true, the hypothesis according to Whewell should be regarded as a valid one Mill criticises Whewell and does not regard this as a valid test of a hypothesis For correct predictions may be made through the help of two hypotheses only one of which is afterwards established. Thus eclipses were precisely predicted in the Ptolemaic as well as in the Copernican theory and yet the two theories are in no way compatible only the latter is

now universally accepted as valid. Verification as is shown in the above section is not proof. Moreover, it might be said, that prediction has a certain persuasive effect without there being any scientific basis for the same. When a theory enables us to predict some phenomena, it produces more or less a certain mental bias in its favour, puts us off our guard, and the scientific pursuit of the problem is in this way liable to be defeated or evaded

15. HYPOTHESIS FACT. THEORY—The word Hypothesis is contradistinguished from the words Fact and Theory. These latter words, however, are ambiguous. By fact we often mean any thing observed by our senses. Thus an eclipse is a fact, because we see it with our eyes. But the agency of *Râhu* is not a fact, because we do not see it So with the perceptions of the other senses. In contrast with the word 'fact', the word 'theory' is often used to designate hypothesis which is suggested but not yet proved Thus even before Newton's Law of Gravitation was proved, the words "Theory of Gravitation" would have been regarded as quite legitimate. The word theory is very often used to point out a proposed theory (a hypothesis). But according to some writers, the word theory should be restricted in its application, and only a proved hypothesis should be designated by the word. When this is so, a theory is a fact, meaning by a fact not simply a thing perceived by our senses, but any thing, state of things, or relation of things perceived by the mind to exist. The narrower and the broader meanings of "fact" are closely related, for the existence of a thing may be grasped by the *mind* or by the *senses*, and the two kinds of grasps have after all the same basis

16. HYPOTHESES NON FINGO:—Bacon raised a note of protest against the use of Hypotheses, and Newton said "*Hypotheses non fingo*:" "I do not imagine hypotheses" Such a disparagement of hypotheses in general, is not justifiable Progress in knowledge can never be made without allowing the free play of the imagination Some hypotheses may be rightly guessed, whereas many might be incorrectly guessed Some scientists seem to have as it were an instinctive grasp of correct laws; they guess the right hypotheses at once, as if their heads are made according to Nature Whereas some scientists like Kepler have to make guesses after guesses till at last the correct hypothesis is arrived at The ordinary disparagement of hypotheses is due to the fact that the imagination is hardly curbed by people and many absurd hypotheses pass current when the mind is in a biased condition To such hypotheses the condemnation of Bacon and Newton may be applied invariably When Newton said "*Hypotheses non fingo*" he meant by Hypotheses, assumptions which are not based on any experience and have no analogy with the same he meant illegitimate or barren hypotheses Hence such hypotheses can be neither proved nor disproved It does not however follow that no hypothesis should be framed For the matter of that, Newton himself invented many hypotheses, and the Law of Gravitation is nothing but a result of a hypothesis Even Bacon, though he disparaged the Deductive Method and Hypotheses, was obliged to resort to hypotheses under the designation of *permissio intellectus*, and *interpretatio inchoata* (free play of the intellect and inchoate interpretation of nature by the imagination).

17. CRUCIAL INSTANCES —When there are rival hypotheses or some questions which involve a point at issue, and some observation or experiment decides it, the instance

is designated a *crucial instance. Crux* means a sign—post, and a crucial instance serves as a sign—post at the parting of two ways Just as a sign—post points out the path required, so a crucial instance points the way to truth The essence of a crucial instance is that it should be compatible with *one and only one* hypothesis, i e, *it should confirm one hypothesis and at the same time negative the conflicting hypothesis or hypotheses*." One single circumstance, which admits of one explanation *only* " says Ueberweg "is more decisive than a hundred others which agree in all points with one's own hypothesis, but are equally well explained on an opposite hypothesis." (*Logic*, English Translation, p. 513) Two illustrations might suffice to make this clear Suppose a man usually takes part in public meetings, takes up the cause of the public, and always tries to show that he is working disinterestedly But his conduct might be shown to be compatible with two theories. He might be doing the work to win public favour, to come into prominence, and thereby win popularity and support in his profession Or, he might be doing the work simply from a love of service to the country All along he might show honesty, consistency, and sincerity in his activities. But these are qualities which are compatible with both the theories Suppose, however, that on a particular occasion, he upholds a position not liked by the people and this renders him unpopular. Suppose further that there is regular opposition to him from the public and his conduct can be shown to be consistent only with love of service to the country and *with nothing else* Any instance when such an occasion comes, would be a crucial instance, and if the man carries on his orginal policy, even under circumstances such as these, there is only one as-

sumption which holds, and that is, that of disinterested work. This is a crucial instance from observation A crucial experiment or crucial instance from experiment may next be taken Chemists in the last century when they performed experiments of calcination, observed that metals gained in weight by this process (being reduced to powder by heat) How can this happen? It can be accounted on one of two assumptions, either something was added to the metals, or something which was light was driven off from them in the process of calcination The latter alternative was supported on the hypothesis that a light substance, namely, phlogiston had been driven off from the metals Lavoisier performed an experiment which decided which of the two alternative hypotheses was correct. He hermetically sealed some tin in a glass retort, weighed the whole, heated it, and when the tin was calcined, reweighed the same The weight was the same When the retort was cool, he opened it and some air rushed in From the rushing in of the air it was evident that some of the air formerly within had disappeared Again the whole was weighed, and it then increased in weight by about 10 grains. This was the quantity of air which entered when the retort opened When did the 10 grains of air disappear? The whole was airtight The calcined tin was weighed, and it was found exactly by 10 grains heavier than when it was placed in the retort Nothing had gone out during the process, i e., there is nothing like Phlogiston, and something had combined with the tin during calcination, namely, the 10 grains of air which had disappeared Of the two alternative hypotheses only the first was found valid, and the second was decided against by this experiment, which thus served as a *crucial experiment* against phlogiston

Note 1 GRATUITOUS HYPOTHESES These are hypotheses which may be shown to be unnecessary Fowler explains a gratuitous hypothesis as "the assumption of an *unknown cause* when the phenomenon is *capable of being explained by the operation of known causes*, or the introduction of an *extraneous* (*though it may be known*) *cause* when the phenomenon is *capable of being accounted for by the causes already known to be in operation*" The crystalline spheres of the ancient astronomers illustrate the former type of a gratuitous hypothesis, because such spheres are *unknown* and the planetary motions are explicable on other astronomical theories too well known. The latter type of a gratuitous hypothesis may be illustrated by an assumption that some one is instigated by some one else in some evil action, when, as a matter of fact, he himself might have evil propensities of his own from which the action really originated

2 BARREN HYPOTHESES Those hypotheses which are incapable of verification are called barren hypotheses The supposition that a national success is due to divine favour, that cholera, plague, and other epidemics are prevented by sacrifices to appease certain deities, and such other suppositions would be barren hypotheses, for they cannot be proved or disproved A barren hypothesis is the opposite of a good (legitimate or permissible) hypothesis Such an hypothesis should be distinguished from a false hypothesis A barren hypothesis is simply not good, *i e*, is illegitimate not being capable of proof or disproof, it should not be maintained But a false hypothesis is quite legitimate, but rejected, because it does not explain all the facts, e. g, the Ptolemaic Theory

Note 3 VERA CAUSA Newton laid down certain rules for testing a hypothesis His first rule was

"No more causes of natural things are to be admitted than such as are both true, and sufficient to explain the phenomena of those things"

The question is, what did Newton exactly mean by a true cause (*Vera causa*) ? The usual answer would be that he meant by it a cause *independently known to exist* Ueberweg said that a *vera causa* is a cause " already shown to exist as an actual power in nature" Is such a restriction accepted by all? It cannot be, because very often in the explanation of nature one has to make leaps in the dark Mill's

idea about a *vera causa* is not such a restricted one "It is" he says "certainly not necessary that the cause assigned should be a cause already known, otherwise we should sacrifice our best opportunities of being acquainted with new causes" (System of Logic III XIV 4) Newton wanted to exclude the imagination of causes of whose existence we have no direct knowledge, e g, the Vortices of Descartes But the restriction is *strict* In the explanation of phenomena science has to conceive of causes not known to exist, e g, the connection of diseases with bacilli So a *vera causa* cannot mean *a cause already known to exist*

Nor can it mean a cause directly *perceived* by us For this would exclude some of the most useful theories of science, e g, the atomic constitution of nature, since atoms are not perceived

A *vera causa* is a cause which is *in real and necessary connection with the phenomena to be explained* It may not be known to be existing, it may not be perceivable But its connection with the facts under consideration must be real this should be established in a way acceptable to experience It must at least be analogous to an existing cause If it is not perceivable at least its effect should be manifest or perceivable, at least its effect should be manifest or perceivable The planet Neptune was imagined to account for certain anomalies in the motions of Uranus Neptune was not perceived when the hypothesis was framed But still the influence of this planet on Uranus was a *vera causa* Supposing it existed it would produce some influence which would be *like* the influence of the known planets The unknown planet was a *vera causa* even before it was discovered, because it was supposed to influence Uranus in a way analogous to that of the known planets it was supposed to be in necessary connection with the perturbations to be explained

Note 4 ABSTRACTIONS AND HYPOTHESES Sometimes it is asserted that the truths of Geometry are based on *hypotheses*, e g, a line without a breadth, a point without a position, and so on The hypothesis here, would be that geometrically things exist as they are defined Actually they do not so exist, but we assume that they do These are *abstractions* from concrete things, and simply because the assumption of certain omissions is made, they are loosely spoken of

as *hypotheses* The word hypothesis is here identified with abstractions and treated as opposed to concrete objects There are, similarly, convenient fictions in Mechanics (a bar supposed to be absolutely rigid) in Economics (the theory that man is moved by love of gain) and so on These are, however, better designated by the word *abstractions* There seems to be no solid ground for speaking of them as hypotheses, for whereas an hypothesis proposes the existence of some agent collocation, or law for purposes of explanation, an abstraction proposes the absence or exclusion of certain things known to be present in concrete objects The two are different and the word Hypothesis is wrongly applied to such abstractions

NOTE 5 REPRESENTATIVE FICTIONS Sometimes hypotheses are framed in connection with the minute structure and operations of bodies Now such hypotheses can never be strictly proved for the minute structure and operations of bodies evade examination Hence if the hypotheses in question suitably express the phenomena in question their function is fully served, they may not be proved, yet they may suitably express the given phenomena They are even then very useful and are designated as *Representative Fictions* Bain gives as an illustration the theory that heat consists of motion in the atoms of a body This cannot be directly proved If, however the assumption conveniently represents the phenomena of heat it is a good hypothesis (being designated a Representative Fiction) The Undulatory Theory of Light even though it may not be fully established, serves to describe the phenomena of Light very conveniently Hence it is another illustration of a Representative Fiction

NOTE 6 WORKING AND DESCRIBING HYPOTHESES A working hypothesis is a hypothesis which is more or less provisionally accepted as an hypothesis The root-idea which is the basis of a working hypothesis may be called a working idea Even if a hypothesis is not proved and is finally disproved it does not follow that it is useless, for it might be very convenient for the purpose of describing the facts to be explained To treat electricity as a fluid is such a hypothesis For we know that electricity is not a fluid and yet to speak of it as a fluid is a convenient way of collecting and describing some of the known phenomena of electricity So the Ptolemaic hypothesis in astronomy

may be regarded as a working hypotheses It is essentially false yet it describes the facts as conveniently as the Copernican theory This shows that two or more working hypotheses may at once be useful and serviceable though only one may explain the facts correctly Very broadly any hypothesis at its initial stage i e, when it is useful as provisionally describing the facts, may be called a working hypothesis

Note 7 HOW ARE HYPOTHESES SUGGESTED ? The following are the principal means which suggest the formation of hypotheses —

(1) Method of Agreement,

(2) Conversion of Propositions

and (3) Analogy

(1) We observe that event X accompanies certain instances A B, C, D, E and so on and we notice further that event Y accompanies them Hence we attempt to connect X with Y if X precedes Y we assume that X is the cause of Y. Thus A, B C, D, E may be individuals They took a certain tonic say Huxley's *Nervigor* and a certain consequent followed, namely, improvement in health The X and the Y are there and we naturally connect X with Y as cause and effect This is too simple an illustration Yet it shows very aptly how a hypothesis might occur to the mind So when an epidemic occurs in a city people leave the affected localities Those who leave it do not suffer There is agreement in one fact namely being free from attack outside the affected locality The hypothesis might naturally suggest itself under these circumstances that the disease circulated through some poisonous atmosphere In this way even in the problems of science it is agreement which is a principal means suggesting a hypothesis

(2) When a universal judgment is formed and a connection between two facts or events established, we naturally raise the question whether it is a reciprocal connection "All S is P" is a universal proposition it says that wherever S is P is the mind naturally asks the question whether wherever P is, S also will be ? Is the conversion of the proposition, "All S is P simple or *per accidens*? If it is simple, the connection between S and P is not casual, but may be causal. A hypothesis may consequently be framed under such circumstances, and it may be seen whether it is justifiable and may be established. Thus, the proposition, "all men are mortal" cannot be simply convert-

ed i.e. "all mortals are men" is not inferable from it. Hence there is no reciprocity between the subject and the predicate here. Humanity, therefore, has as such nothing to do with mortality. But if a proposition which can be simply converted is given to us, we naturally frame a hypothesis that the subject and the predicate terms are connected in a closer way. Thus, the proposition, "all living organisms are subject to death" is simply convertible, and therefore, the assumption is rightly suggested that the ground of death lies in organic life.

(3) Thirdly, hypotheses are suggested by Analogy. This is a very potent means. As Lotze says: "A successful hypothesis is always due to the attention paid to analogies." Thus the famous Newtonian theory was suggested on the analogy of a falling apple. The early researches of Pasteur in bacteriology were suggested by certain analogies. The old theory asserted that contageous diseases were due to the introduction of *virus* poison into the blood. The new theory asserted analogically that a contageous disease was caught by the blood, but in a different way. The analogy went so far that the second theory asserted like the first and the old theory that the blood was affected. The blood was affected by the introduction of *virus* or poison, said the old theory; it was affected by the introduction of minute animalcula, said the second theory. The hypothesis was then proved experimentally to be true. It was suggested by an analogy and it turned out to be true. The discovery of the planet Neptune was due to a hypothesis suggested by an analogy. Deviations in the orbits of planets other than Uranus were known to be due to the influence of these planets on each other. Hence it was assumed analogically that the deviations of Uranus were so caused. But the influences of the known planets on Uranus could not account for the whole of the deviation of Uranus. A residual fact remained for explanation and this, it was assumed, was due to some unknown planet. This hypothesis turned out to be correct, for the planet Neptune was discovered subsequetly.

QUESTIONS

(1) Distinguish between Observation and Experiment. Show that under certain circumstances one can only resort to observation.

(2) What precautions are needed in Observation ?
(3) What is the false method of induction against which Bacon protested vehemently ?
(4) Classify the following sciences accordingly as they employ observation, experiment, or both —
Astronomy, Physics, Chemistry, Zoology, Botany, Psychology, and Sociology
(5) How do you distinguish Deductive and Inductive classification ? Define classification
(6) Enumerate the essentials of a good classification
(7) How is classification subsidiary to Induction ?
(8) How do you distinguish natural from artificial classifications ? Give illustrations
(9) What purpose does natural classification serve
(10) What purpose does artificial classification serve ?
(11) Criticise the statement *Hypotheses non fingo*
(12) What is a hypothesis ? Show that it is very useful in ordinary as well as scientific explanations
(13) What are the essentials of a good hypothesis ?
(14) Explain the meanings of the words Theory, Fact and Hypothesis
(15) What is a *vera causa* ?
(16) Distinguish between the abstractions of mathematics and hypotheses
(17) What is a crucial experiment ?
(18) What are gratuitous hypotheses

CHPTER VII

THE INDUCTIVE METHODS

1. THE LOGICAL CHARACTER OF THE INDUCTIVE METHODS —Induction is generalisation from experience In what is known as Imperfect or Scientific Induction we make inferences from the known to the unknown. In order to do this, certain assumptions have to be made

These are the grounds of induction While making inductions we have to resort to observation or experiment or both. Further, hypotheses have sometimes to be framed, and we noticed that much help is given by the classification of facts and phenomena Having, however, made an induction, where is the guarantee that it is correct? How shall we test it? Supposing that we have made an induction that event A is the cause of event a, how shall we test its validity? A reply to this question is supplied in what follows. The Methods of Induction, or as they are better designated the Inductive Canons "describe the character of observations and experiments that justify us in drawing conclusions about causation" Just as in Deductive Logic, the rules of a syllogism enable us to test the formal validity of deductive inferences, so in Inductive Logic the Inductive canons enable us to test formally the validity of material inferences about causation

7 THE INDUCTIVE METHODS: Mill enumerated five methods, or rather canons for investigating facts of causation He was not the first to mention them In fact, Herschell had already described them before the time of Mill However, Mill was the first to popularise them. They are the following —

(1) The Method of Agreement,
(2) The Method of Difference,
(3) The Joint Method of Agreement and Difference,
(4) The Method of Concomitant Variations,
and (5) The Method of Residues

(1) THE METHOD OF AGREEMENT

8. THE STATEMENT AND EXPLANATION OF THE METHOD OF AGREEMENT:—Mill states the canon or rule of the Method of Agreement in the following words:

If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause or effect of the given phenomenon.

This rule when analysed implies the following conditions :—

(a) There should be *two or more instances* of a phenomenon to be investigated:

(b) Which instances should have *only one circumstance* in common

When this is so, the circumstance *in which there is agreement* is the cause or the effect of the given phenomenon, (accordingly as it is the antecedent or the consequent)

Symbolically the rule may be illustrated thus: Let A represent an antecedent, and *a*, a phenomenon which follows. Now in nature complex phenomena precede and complex phenomena succeed them, analyses have to be made by us things are never given analysed. A therefore, would occur with certain other things say B and C, and the consequent also would occur as a complex whole, i. e., in combination with the consequents *b* and *c* Now, if we suppose that the antecedents and consequents are as under

Antecedents		Consequents
A B C	followed by	*a b c*,
A B D	,,	*a b d*,
A C E	,,	*a c e*,

we may reason out that A and *a* are probably cause and effect. For we know that ABC is followed by *abc*. Now *a* is the effect to be investigated It may have been produced by A or B or C. But C has nothing to do with it for in the second instance we have A B D followed by *a b d*,

i. e., C is absent and yet *a* is present Further B has nothing to do with *a* for it is absent in A C E which is followed by *a c e*. In the group A B C followed by *a b c*, we therefore connect A with *a* causally In *two or more instances* of the phenomenon *a* to be investigated here, we notice that there is agreement in *only one circumstance* namely that whenever A precedes, *a* follows, therefore, we connect these two causally

We often carry on arguments in this way. Suppose that a particular individual is distinguished for his bowling and that he is a cricket-captain From the fact that two or three teams under him forming different elevens were successful on the field we would infer causation and say that he was the cause of the victory. Three victories won by three teams in which only the captain is common suggest that the victory is due to the presence of the particular captain we suppose. Now in this example the play is followed by victory Play however means a very complex fact It means the use of the skill of the different individuals who constitute the eleven, a particular kind of ground, a particular kind of materials, and so on In the complex phenomenon play, we mark out one element, the part due to the presence of the individual in question, and designate it by the symbol A. The part due to the skill of the remaining ten players is in an elementary way, say, X_1, X_2, X_3 ...to X_{10} The combined part for convenience's sake may be designated as B Then the quality of the ground may be G, that of the weather, W, and that of the materials, M, or for convenience the G, W, and M together may be represented by C. Then we have

A B C
a b c

i e, a certain team on a certain ground with certain materials and under certain weather conditions wins the game, i e, *a* happens *b* and *c* we might suppose to be the partial contributions of B and C

Again we have

A B D	and A C E
a b d	*a c e.*

With different teams and on different grounds &c, the results agree in one thing, namely, success This then, we say, is due to the Presence of A.

Here to a certain extent we have seen the invariable connection of A with *a* (Further, the accidental antecedents of a and the accidental consequents of A are *eliminated*) We have *varied the circumstances,* we have taken cases in which A is present, but other circumstances are different, and yet one aspect of the result is the same, namely, victory This is what enables us to say that A and *a* are causally connected We take *negative instances* of C and B, for we take A B D followed by *a b d*, and A C E followed by *a c e*, i e, C and B are respectively *absent* and yet *a* follows. Further *c* and *b* are not the effects of A, because they are *absent* in the consequents *a b d* and *a c e* respectively We thus eliminate the accidental consequents of A and the accidental antecedents of *a*, after having taken negative instances into consideration This case, therefore, differs from a simple repetition of A B C followed by *a b c* for two, three, or four, or more times Such a case would be an exemplification of the application of simple enumeration Because we *eliminate* we are not making use of Induction per simple enumeration. The Method of Agreement thus differs from simple enumeration, since it is based on *elimination,* which the latter is not

4 DIFFICULTIES CONNECTED WITH THE STATEMENT OF THE METHOD — Facts as they are observed in nature are seen as complex wholes Events are not marked off as separate phenomena. The method, as it is stated, however, takes it for granted that the facts are separated The *a*, *b*, *c*, *d*, and *e* do not occur separately or distinctly They are found together as complex wholes. Once the act of analysis is made, it is easy to see that A followed by *a* is invariably present in two or more instances The difficult part of the work is, however, the separation of *a* from *b e* or *c e* and so on. The work of separating the elements of a phenomenon is not as easy as the work of sorting out letters in a post office. Yet, this is what the Method assumes Secondly, it is very difficult to prove that the instances have *only one* circumstance in common. Artificial cases may be imagined in which such a condition may be easily satisfied Otherwise, in nature it is difficult to prove that only one circumstance is common in certain phenomena. Even in a simple case this is difficult to prove Thus, if two or three patients who are in a convalescent state of health, find considerable improvement by taking a particular tonic, it would be difficult to say that *only one* circumstance is common here The individual constitutions differ The tonic is common. When, however, it is taken, a certain kind of mood in the three men may be common, a certain refreshing and invigorating weather may be common, and so on It would be really speaking very difficult to decide that *only one* circumstance is common to the instances examined. Thirdly, the method takes for granted that any combination of the antecedents is admissible Thus we take A B C, A B D, A C E, (A B E, A E F, and so on). This holds good only

of a very limited number of cases For in the concrete illustration discussed, we might have cases of different grounds, different materials, and so on But such a free scope for combinations is difficult to get in many actual cases The method takes it for granted that we can pass on from a case A B C to a case A B D But it hardly occurs that when C is taken away, and D substituted, A and B remain unaffected, i e, remain A B. For suppose A B C represents a tonic (A) taken by an individual (B in a particular climatic condition (C) Suppose the last is changed and we get D. Will the properties of A remain the same ?

5 THE SYMBOLS USED BY MILL'—In the explanation and illustration of the Method of Agreement we made use of the symbols A, B, C, D, E, &c, and *a*, *b*, *c*, *d*, *e*, *etc* These are the letters used by Mill Some logicians object to the use of these letters, for the large and the small letters create as it were a bias in the mind We are prejudiced to a certain extent and at once connect A with *a*, B with *b* and so on Half the work is thus simplified This connection is *to be established*, *to be yet found*, and should not be given, at any rate, the mind should not be kept prepared to take up the connections A *a*, B *b*, and so on Hence a different symbolic representation is preferable. It would be as under —

Antecedents	Consequents
A B C	*p q r*
A D E	*p t s*
A F G	*p u v*
and so on	

Here there is agreement only in A followed by *p*. When we pass from A B C to A D E we have agreement in A

only. So when we pass from the consequents *p q r* to *p t s* we have agreement in *p* only *p* cannot be due to B or C, for in the second illustration B and C are absent, and *q* or *r* is not due to A for in the consequent *p t s*, we have A as antecedent but yet *q* or *r* is not present This is how we establish that A and *p* are connected as cause and effect. This kind of symbolic representation is superior to Mill's, because it has no suggestions in it, whereas Mill's representation has the merit of simplicity in its favour

6 DEFECT IN THE METHOD OF AGREEMENT —The Method of Agreement is not completely satisfactory as a method. Over and above the difficulties noted above, there is a radical defect in the method itself If we recognise the possibility of there being a plurality of causes (for ordinary purposes we do, and even scientifically some logicians recognise it), the Method of Agreement will not test causation satisfactorily. For we have A B C followed by *p q r*, and A D E followed by *p t s* If we recognise a plurality of causes, it may happen that in the first instance B was the cause of *p*, and in the second, D. B is absent in the second instance, yet *p* happens and it may be that there it may have D as its cause Thus B and D may have caused *p* alternately. A is present in both instances, yet it may be quite an accidental accompaniment of B or D the causal antecedent Thus suppose three men are administered three different poisonous drugs in water The result will be death Yet surely the common accompaniment, namely water has nothing to do with it Symbolically, we have the following

A B C followed by *p q r*
where A might represent water,
B „ opium,

C might represent the physical constitution of the first individual

Similarly we have

A D E followed by *p t s*

where A might represent water,

D „ *dhatura* (another poison),

E „ the physical constitution of the second individual

Thirdly we have

A F G followed by *p u v*

where A might represent water,

F „ diamond-dust,

G „ the physical constitution of the third individual

The consequent death is common in the three instances, and therefore *p* means death The letters *q r t s u v* will represent the chemical and other changes which accompany the cessation of life in the three cases Evidently *p* happens in the three cases, and yet, A the common antecedent has nothing to do with the production of the effect The causes are many There is here a plurality of causes, namely B, D, F, and therefore, the Method of Agreement gives us an unsatisfactory test of causation. The weak point of this method, therefore, is that it is liable to be frustrated by a plurality of causes

Sometimes Agreement is connected with the fact that the two phenomena *A*-*p* are simply co effects Thus whenever the hour-hand moves five minutes (an hour) the minute-hand moves sixty minutes Whenever a gun is discharged, a flash of light and a sound precede and follow regularly Yet the movements of the hour-hand and the minute-hand are co effects of the working of the machinery

of the clock So the flash of light and the sound are also co-effects The A and the *p* here are simply connected through a fact of causation. The Method of Agreement is therefore liable to be frustrated in a double way, 1stly by a plurality of causes, and 2ndly by the fact that the phenomena which have antecedence and sequence may be simply co-effects.

If, however, the Method of Agreement is thus lible to be frustrated, why should it be recognised as an inductive Method at all ? The reply is that though the weakness is a real one, yet there is a means for avoiding it. If we multiply the instances, and vary them as much as possible, the possiblity of an error due to a plurality of causes will become less and less probable If the number of instances is very large and varied, practically there will be no room for this error. If the instances are repeated more and more, besides the phenomenon investigated (e g, death) there will be found to be an agreement in one circumstance(e. g. taking opium, or diamond dust) which will be rigthly spoken of as the cause The chance of an inert substance being mixed with two potent substances (e, g water with two kinds of poison) and being connected with the phenomenon (death) as the cause, may be obviated by varying the circumstances as much as possible (i. e, seeing how the same poison acts when mixed with water, *sherbat*, and so on)

7 THE PECULIARITIES OF THE METHOD OF AGREEMENT: We have noted one peculiarity of the Method of Agreement It is that it is liable to be frustrated in its logical test by a plurality of causes Further, it is worth noting that it is mainly a *Method of Observation*, and consequently it is mainly used for the purpose of determining

the *causes of given effects* rather than the effects of given causes Moreover, *when we want to find out the causes of a given effect*, the Method of Agreement is the Method to which *we resort in the first instance* The reason of both these peculiarities is obvious We can only resort to observation when we have to proceed from effects to their causes, we cannot experiment in such a case, it being naturally impossible We begin by collecting like cases of the effect in question, then note the agreement, and then determine the causal antecedent by this Method. The result may be verified by experiments, and tested by the Method suited to experiments But in the first instance, the test is, that which is supplied by the Method of Agreement

The Method of Agreement is not very useful when we resort to experiments When our control over phenomena in limited, we cannot experiment on them, and we have simply to observe how they occur In such cases we note the agreement required by the Method of Agreement If we can experiment with ease, we have other methods more suited to experiment

8. THE METHOD OF AGREEMENT DIFFERENTLY WORDED. Since the Method is liable to be frustrated by a plurality of causes, some logicians regard it not as a *final* or conclusive test of causation, but only as being a preliminary test of the same. It will thus afford not a proof of causation, but will only be a stage in scientific inquiry It prepares the way for the application of other and safer Methods Hence Mellone would like to bring out its real significance by changing Mill's wording thus —

"*When observation shows that two events accompany one another (either simultaneously or in succession), it is probable*

that they are causally connected, and the probability increases with the number and variety of the instances"*

ILLUSTRATIONS:—

(1) The following example from Bain's Logic is easy and interesting

The *North-East* wind is in England *injurious* to many persons The question is, what is it due to? The elements of wind are mentally analysable into (1) the degree of violence, (2) the temperature, (3) the humidity or dryness, (4) the electricity, and (5) the ozone Let observation be made use of and let us collect as many instances of this wind as possible, and then see which element is invariably or uniformly present in it. When this is done it is found that the North-East wind differs in *violence* at different times, it is generally feeble, yet at occasions stormy. The injuriousness therefore, does not follow from the violence of this wind As regards *temperature*, it is often cold, yet sometimes comparatively warm Sometimes it is wet, and sometimes dry, hence there are differences in *humidity* As to *electricity* there is no constant electric charge And as regards *ozone* it contains less of it than the South-West wind, yet in some places, e g, at the sea-shore, it has more of ozone than the North-West wind in the heart of a town. Hence none of these five elements is the cause of the injuriousness There is one thing in addition, and that is always present when this wind blows. It blows from the pole towards the equator, and for thousands of miles blows *close on the surface of the earth* Thereby, it might be imagined, that many impure elements-dust, effluvia, germs necessarily charge it In all cases of this wind, there is agreement in this circum-

* (*Introductory Text-book of Logic, p 277*)

stance, and it is the antecedent to the injuriousness which follows Hence by the Method of Agreement we may infer causation; at any rate causation is highly probable.

Symbolically the case may be thus argued.—

The North-East Wind : cause of its injuriousness.—

Antecedents	A.. ... .being ground current	
	B . . .feeble	
	C .. .. ..cold	
	D... . ..wet	
	E . ... . positive charge of electricity	
	F . .. ..less ozone	
Consequents	*p* . .... . injurious	
	q . . ..current feeble	
	r .. .. . " cold	
	s .. .. . " wet	
	t . .. .. " containing positive charge	
	u .. .. " less ozone	

Again we have

Antecedents	A	
	B_1, ...violent	
	C	
	D	
	E	
	F	
Consequents	*p*	
	q_1, ...current violent	
	r	
	s	
	t	
	u	

So there are changes in C, D, E, and F, and in *r*, *s*, *t*, and *u* All circumstances except A and *p* change. Hence *p* is not connected with B, C, D, E, or F, nor is A connected with *q*, *r*, *s*, *t*, or *u*, for they are all changing and disappear when A is present. A and *p* are thus connected closely. The one precedes the other Therefore A is the cause of *p*.

We feel sure in saying that A and p are causally connected, because over and above the agreement i. e., the inductive basis of the proof, there is a certain *presumption* deductively supported in this case. The current being a ground-current must naturally carry many impurities like dust, microscopic bacteria, and injurious effluvia. Moreover, the result is borne out also by another inductive method. But of this later on.

"*If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save one, that one occurring only in the former, the circumstance in which alone the two instances differ is the effect or the cause or an indispensable part of the cause, of the phenomenon*"

When analysed the rule means that

(1) there should be *two instances* of a phenomenon,

(2) they should have *all circumstances, save one in common.*

If these conditions are fulfilled, the circumstance in which alone there is a difference is the effect, or the cause, or an indispensable part of the cause of the phenomenon.

Symbolically the rule may be illustrated as under —

Antecedents		Consequents
A B C	followed by	*a b c*
B C	,,	*b c*

If the suggestions created by B *b*, C *c* are to be avoided the following would be preferable

Antecedents		Consequents
A B C	followed by	*p q r*
B C	,,	*q r*

We have in the Method of Difference two and only two instances The two groups of sequences differ from one another in only one circumstance, which is present in the first, but absent in the second Thus A B C gives *a b c* and B C, *b c*, only one element disappears from the group of antecedents and only one disappears from the group of consequents. Nothing can be more clear than this. A and *a* must be causally connected. To say that the disappearance of A and A alone, is followed by the disappearance of a and a alone, means that the presence of A had a causal connection with the presence of *a*

Difference plays a great part in our everyday life as Bain says We expect to do certain things and achieve certain results on the implied basis of the method of Difference Thus we feel warm We fan ourselves and are quite sure that fanning is the *cause* of the relief we get For here we have the sequence A B C—*a b c*, and then the sequence B C—*b c* The A or the closeness and warmth in the room is removed by the fanning, and consequently, *a* (or langour and bodily discomfort) is also removed We are quite sure that only one circumstance disappears because the change from A B C to B C is immediate and simple. We take up a fan and begin fanning. Of course, many changes may take place in the room where we are, in connection with our body. Thus there may come from the window a gust of wind, or some one may curtain the window, or he may fan himself in the room and currents of air thus set in motion. may affect us, and so on We know, however, that in the illustration in question, nothing like this has happened. Our fanning, thus, is the cause of the relief we get So when we remove the darkness of a room by pressing an electric switch, we rightly infer causation, because the change from darkness to light is instantaneous, and there is no scope for any intermediate third something turning out to be the cause of the phenomenon of light.

The Method of Difference is so simple and efficaceous in its application, that we use it perhaps more often than any other method. Carveth Read says· "Now this method of Difference is perhaps oftener than any other, though without our being distinctly aware of it, the basis of ordinary judgments. That the sun gives light and heat, that food nourishes and fire burns, that a stone will break a window or kill a bird, that turning a tap hastens or checks

the flow of water or of gas, and thousands of other propositions are known to be true by rough but often emphatic applications of this method in common experience."* The reason of this is evident The principle on which the Method rests is very simple What more simple than to understand that (other things remaining the same) if an agent disappears and something else also disappears in a phenomenon, the two are causally related? *Only one* agent disappears, and *only one* element in the result disappears The causal sequence is evident The difficulty consists only in making sure about this But if we are sure that only one circumstance has disappeared and is followed by a disappearance of one element in the consequent, there is a causal connection without the least doubt.

10 THE PECULIALITIES OF THE METHOD OF DIFFERENCE CONTRAST WITH THE METHOD OF AGREEMENT — The Method of Difference is essentially a Method of Experiment just as the Method of Agreement is a Method of Observation. It is therefore chiefly adapted to the discovery of the effects of given causes Experiment is greatly useful to us, corroborating the results of observation whenever we want to find the effects of given causes We can take the causes in a certian set of conditions known to us, experiment with them, and see whether a certain result follows or not At times, the application of the Method of Difference may be made without the help of any experiment, because Nature may herself provide us with the positive and negative instances. But these are exceptions. *As a rule, the Method is a Method of Experiment* just as the method of Agreement is a Method of Observation

* Logic, Deductive and Inductive, p 208

Both the Methods are Methods of *elimination* The difference between them, in the words of Mill is that "the Method of Agreement stands on the ground that whatever can be eliminated is not connected with the phenomenon by any law. The Method of Difference has for its foundation that whatever cannot be eliminated is connected with the phenomenon by a law."* Elimination is exclusion Now, in the Method of Agreement we have A B C—*a b c*, ABD—*a b d*; A C E—*a c e* Here B, C, D, E and *b*, *c*, *d*, *e* can be eliminated, and only A *a* always remains, or is uniform. Therfore, B, C, D, E and *b*, *c*, *d*, *e* have nothing to do with the causal sequence What is eliminated without affecting the causation is thus not connected with the phenomenon by any law. In the Method of Difference we have ABC—*a b c*, and BC—*b c* The two instances agree in having B C—*b c* A *a*, however, cannot be eliminated, because where A is, *a* is, where A is not, *a* is not In the Method of Agreement there may be two or more instances, they agree in nothing except in the possession of two circumstances (antecedent and consequent) which are common to all instances. In the Method of Difference there are only two instances, they agree in everything except in the possession of two circumstances (antecedent and consequent) present in the one and absent in the other instance The Method of Agreement is so called because we collect instances to see in what points the agreement consists, whereas the Method of Difference is so called because we see the points of difference between the two instances.

As a consequence of this difference, another peculiarity of the Method of Difference follows, and it is worth

* (System of Logic, BK III viii 3)

noticing The Method of Agreement is not completely satisfactory For it is liable to be frustrated by a plurality of causes But the Method of Difference is satisfactory in its results, provided we are quite sure that the difference exists only in one particular With the help of this method, we can *with certainty test causation* Thus by the Method of Agreement we find that A B C, A B D, A C E are invariably followed by *a*, and *a* is the invariable consequent of A But where is the guarantee that A is a *cause* of *a*? By multiplying instances the connection A *a* is seen to be very probably causal Yet the assurance that A is a cause of *a* can come to us with certainty only when from A *alone* we can produce *a*. And this is what the Method of Difference enables us to do The Method of Agreement suggests the applicability of the Method of Difference, which alone proves causation with certainty The only difficulty in the application of the Method of Difference consists in making ourselves sure that the difference in the two instances exists only in one particular This need not, however, affect the value of the Method as such

ILLUSTRATIONS:—

(1) The crucial experiments in science are all dependent on the application of the Method of Difference In the Science of Chemistry, which is essentially an experimental science, an agent is introduced in the midst of a number of known circumstances and the change noted and attributed with confidence to the introduction of the new agent

(2) The coin and feather experiment, which proves the action of the resistance of air as the cause why heavy and light substances do not fall to the ground in the same time, is a good illustration of the Method under discussion

A coin falls to the ground earlier then a feather. Why? The reply is evident if an experiment is performed. If a coin and feather are allowed to fall in the receiver of an air pump, the air being in, the coin falls earlier and the feather later. Pump out the air from the receiver, and let the two be dropped at the same moment. They will now reach the ground at the same moment. The first was the positive instance, A B C followed by *a b c* the second is the negative instance, B C followed by *b c*. The A represents resistance of air, and *a* retardation of the falling of the lighter substance, namely, feather. Thus we have

Antecedents	A...resistance of air. B ..letting fall the coin. C ..letting fall the feather.
Consequents	*a*. ... difference of time, or retardation of the feather. *b*. . coin reaching the ground. *c*.. ..feather reaching the ground.

In the second instance, we have

Antecedents	B.. ..letting fall the coin. C. ... „ feather.
Consequents	*b* .....coin reaching the ground. *c*... ..feather „

The retardation disappears with the disappearance of the resistance of the air. We are quite sure that no other circumstance has changed The resistance of air, therefore, is the cause of the difference of time in the falls of a light and a heavy substance.

But suppose we take an almost similar case We take a medicine and immediately some relief is got. Is it necessarily due to the medicine? Evidently there is no apparent change but one Suppose a man suffers from

headache and he takes a certain patent medicine The idea that he takes a medicine is itself a potent factor The sentimental change is not taken any note of, and the whole of the change is attributed to the medicine Suppose, further, that one is advised to rub a balm. On rubbing, some relief may be felt Is it certain that the change is due to the balm? Generally we are disposed to say so, as if the rubbing does not reduce any pain Or suppose that a patient is advised to observe certain rules in the matter of diet, habits, and so on. He may be cured of the disease and he may attribute the cure to the medicine But the taking of the medicine is not the only circumstance of which a note will have to be taken. The other circumstances, e. g, avoiding certain injurious diets, bad habits, &c may be more potent or even all powerful and the real cause of the cure. Excepting then in the experiments in Chemistry, it is very difficult to decide that there is a change in only one circumstance and that the Method applies without doubt

(3) Mill gives as an illustration the instance of a man being shot dead All the circumstances immediately before the shot were the same as the circumstances after the shot The wound is the new circumstance and that is due to the shot Hence we say there is a causal connection between the shot and the death Objection is taken to Mill's inference in this case by some logicians on the ground that if it be not for our previous knowledge of the *general adequacy* of a shot to cause death, we should not infer causation in this case We know that a shot is dangerous and hence deductively support the inductive inference. The reply to this argument would be that though practically we do make use of our general knowledge in such a case, yet it

is as a matter of fact not necessary from the logical point of view.

Let the objection, however, be minutely examined To quote Welton: "The Method (of Difference) treated fairly, will not even, by itself, justify the universal proposition that if a man is shot through the heart, he dies. Of course in such a case, we do not argue 'inductively' at all, but deductively from our knowledge of physiology and of fire-arms To really test the Method, therefore, we must put ourselves in the position of one who has no such knowledge, and who has never seen firearms or wounds inflicted by them A person in such a position would not be justified in drawing a universal conclusion The shot has caused death in *this* case, but is it due to the fact that it passed through the heart, or to some individual peculiarity of the man, and if the former, would death always attend such a wound? The Method gives no means of answering such questions"* This objection may be met by saying that the difficulty in this case arises because of the difficulty in deciding that the new agent, the shot, is the *only change* which occurred. If we are sure of this, we are fully justified in inferring causation in the *particular instance* at any rate A man may be of a weak heart and fear itself may kill him. This is another change But if we are sure that in the particular instance, there was no such other change at all and that the only change was the shot, then Mill's argument would be quite valid If the conditions are ideally satisfied in this way the inference of causation is conclusive and based on Induction, not on Deduction That we practically make use of our general knowledge, does not affect the question theoretically viewed.

* (Manual of Logic Vol II, p 154)

(4) Illustrations of the application of the Method of Difference are very easily found in daily life I throw a stone against a piece of glass, and it breaks Causation is evident. I tear this paper and it divides into two Causation is evident. I hold this paper on the flame of a candle, and it burns. Causation is quite evident. And yet why? Because only one agent is newly introduced or one antecedent phenomenon is changed, and that is followed by the consequent in each case The antecedent and the consequent are cause and effect, since the method of Difference applies here quite simply and evidently.

8. The Joint Method of Agreement and Difference

11. The Statement and Explanation of the Joint Method of Agreement and Difference: Mill states the canon of this method as under —

"*If two or more instances in which the phenomenon occur have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect, or the cause, or an indispensable part of the cause of the phenomenon*"

When analysed, the rule has the following elements —

(1) there should be *two or more instances* of the *presence* of a phenomenon;

(2) these should *agree in having only one circumstance*,

(3) there should be *two or more instances* of the *absence* of that phenomenon,

(4) these should *agree in not having only one circumstance* (namely, that which they had in the first set of instances)

If these conditions are fulfilled the circumstance in which alone there is *agreement in presence* in the first set of

instances, and *agreement in absence* in the second set, has a causal sequence.

There are two sets of instances, and the principle is the same as that on which the Method of Agreement depends. The difference is that in the Method of Agreement we have two or more instances agreeing *in the presence of a circumstance*, whereas, here, in addition we have two or more instances agreeing in the *absence of the same* circumstance As there is a double agreement, namely, agreement in the presence and agreement in the absence of a circumstance, the Joint Method of Agreement and Difference is also designated as the *Double Method of Agreement.*

Symbolically the Method may be illustrated as under:-

First set of instances (having the presence of one circumstance in common)

Antecedents		Consequents
A B C	followed by	*a b c*
A B D	,,	*a b d*
A C E	,,	*a c e*

and so on.

Second set of instances (having the absence of the same single circumstance in common)—

Antecedents		Consequents
B C F	followed by	*b c f*
C D E	,,	*c d e*
E F G	,,	*e f g*

and so on

In the first set of instances we have the presence of A *a* in common, in the second, we have its absence.

If we have instances like A B C—*a b c*, and B C—*b c*, we get the Method of Difference In that method we get

two examples exactly similar in all respects save one Thus, in A B C we have B and C in B C, these two are the same There is the absence of only A. Similarly *a b c*, *b c* are similar in every respect, excepting the presence or absence of *a* But in the Joint Method, we have no such exactly similar instances It will be noticed that in the positive instances we have A B C—*a b c*, A B D—*a b d*, whereas in the negative we have B C F—*b c f*, C D E—*c d e* Now in A B C—*a b c*, we have the presence of A *a*, in B C F—*b c f*, we have the absence of A *a* But A B C and B C F *are not in all other respects similar*, for whereas we have B C in A B C, we have F additional in B C F There fore, the condition of the Method of Difference is not satis fied For this reason the two methods are to be distingui shed. Though, however, the Joint Method, does not satisfy the conditions of the Method of Difference, yet by multiplication of instances we may prove by it that in the two sets of instances, though there might be many points of difference, yet we may establish the presence or absence of A *a* The first set of instances shows that when A is pre sent, *a* is present, the second set, that when A is absent, *a* is absent From this we may *indirectly infer* that the method would and is bound to show that A B C is followed by *a b c*, and B C by *b c* Hence the Joint Method is also spoken of as the *Indirect Method of Difference*

Another symbolic representation of the Joint Method would be as under:—

I

Antecedents		Consequents
A B C	followed by	*p q r*
A D E	"	*p s t*
A F G	"	*p u v*

II

B H	followed by	*q w*
D K	"	*s x*
F L	"	*u y*

This representation avoids the suggestion in A B C—*a b c*, and so on.

In both the symbolic representations it will be noticed that the negative instances or the second set of instances come *within the range of facts* as the positive ones. Thus, compare A B C—*p q r* with B H—*q w*, and it will be noticed that B is common to the two. If this is not so, comparison would be impossible With absolute diversity, comparison is impossible

Illustrations of the Joint Method are not difficult to find Thus, if doctors say that vaccination prevents small-pox, and base their statement on the fact that vaccinated districts have it not, and unvaccinated have it, they make use of the Joint Method So in the absence of other complicating circumstances, I find that whenever I take tea at night I lose my sleep, which I do not in its absence The inference is justifiable that the taking of tea plays a causal part in the removal of sleep Fowler says that the Joint Method is being continually employed in the ordinary affairs of life. "If when I take a particular kind of food, I find that I invariably suffer from some particular forms of illness, whereas, when I leave it off, I cease to suffer, I entertain a double assurance that the food is the cause of my illness. I have observed that a certain plant is invariably plentiful on a particular soil; if, with a wide experience, I fail to find it growing on any other soil, I feel confirmed in my belief that there is in this particular soil some chemical constituent, or some peculiar combination of

chemical constituents, which is highly favorable, if not essential, to the growth of the plant."* Of course, these examples are *roughly* illustrative of the Method Only agreement in presence and agreement in absence is noticed, and from that the inference, made. But while noting the agreement in presence, we have not made sure that there is agreement *only in one circumstance.* For example, I take a particular kind of food, say some rich dish in Bombay, and invariably suffer afterwards The occasions differ, only the food is the same Are the conditions of the Method of Agreement fulfilled and may I attribute my complaint to the dish? Decidedly not, for we have *not yet eliminated* the other circumstances Are we sure that the climate of Bombay has nothing to do with it? We can only be sure when we eliminate it The illustrations given, therefore, roughly satisfy the conditions of the Joint Method

While illustrating the Method of Agreement, we took the case of a successful cricket captain Wherever he went, there was success Suppose then, that in the history of of cricket matches, it is further borne out by facts, that wherever he was absent, there was defeat Then we have an application of the Joint Method Now it is highly probable that he was the cause of success Whenever he was present, there was success. In attributing the cause of success to his presence we are not of course quite sure, for there may be a plurality of causes, e g., chance may have operated. But this doubt is necessarily reduced when the teams lost the play in his absence, for if chance operates, why did it not give success afterwards? The possibility of the Method being frustrated by a plurality of causes is almost

* (Inductive Logic, pp 160–1)

nil. The Joint Method approximates to the Method of Difference, though not completely.

12. PECULIARITIES OF THE JOINT METHOD :—The Method of Agreement is liable to be frustrated by a plurality of causes The Method of Difference, and the Joint Method (provided the set of negative instances in it is perfect) are free from this liability. The reason is evident. Thus if two men take the same dose of medicine and recover from a particular complaint, it is probable that the medicine was the cause, yet not certain, because nature, moods, and habits may have operated, the medicine being simply natural in its effect If, however, we can make sure of the absence of other causes as in the Method of Difference, we may be sure in our inference. Thus, in the instance of death due to a shot, Mill is sure of causation, because the result *immediately* follows the shot and therefore *no other change* or cause may be imagined. We have A B C—*a b c*, B C—*b c*, the evidence is clear Oft times, however, the strict conditions of the Method of Difference cannot be satisfied. It is difficult, except in artificial experiments, to get two instances similar in all circumstances save one In such cases the Joint Method is very useful. After having seen a probable case of causation by the Method of Agreement, we try to test it. We can do it by collecting instances of the absence of the phenomenon, and there, if we find the same circumstances absent which were present in the positive instances we are sure of a causal sequence If the negative instances are suitably collected, i, e , if we are sure that *only one* circumstance was there absent, the plurality of causes cannot frustrate the Joint Method. To quote Mill: "In the Joint Method, it is supposed not only that the instances in which *a* is, agree only

in containing A, but also that the instances in which *a* is not, agree only in not containing A Now, if this be so, A must be not only the cause of *a*, but the *only possible cause*: for if there were another, as, for example, B, then in the instances in which *a* is not, B must have been absent as well as A, and it would not be true that these instances agree *only* in not containing A."* Take the illustration from the successful play of our imaginary captain Wherever he is, there is success. By the method of Agreement causation is probable Yet, it is not certain, because chance, or the decided weakeness of the opposite party may be the real cause of success If, however, many games are played, and yet the same event (success in his teams) is observed, there is a high degree of probability of his being the cause. Yet, chance is not totally shut out. And, in all the games, it may be, the competing parties may have been decidedly weak Take, however, the negative instances In his absence, there was always defeat If chance exists, it exists now too If the competing parties are independently and not comparatively weak, they do not now cease to be so If these are *other* causes, or *the* causes, why do they not operate now? If therefore, the fact is imagined, and *only the presence or the absence* of our captain makes the whole difference—success or victory, there is in all probability no doubt that he was the cause of success. The Joint Method, therefore, proves causation, not only so, if the negative instances are many and well selected, it proves that a particular antecedent is the *only* cause of a particular consequent

13 THE JOINT METHOD DIFFERENTLY WORDED.—Mellone takes objection to Mill's statement, and says

* (Inductive Logic, pp 160-1)

that *two* positive instances will never suffice, still less would *two* negative This is true, but Mill does not mean it For he speaks of multiplying the instances He states the canon thus: "Whatever is present in numerous observed instances of the presence of the phenomenon, and absent in observed instances of its absence, is probably connected causally with the phenomenon" The word "probably" is put in, because certainty only comes in the Method of Difference, for reasons discussed and noted

ILLUSTRATIONS

In England the North—East wind is injurious to the health of many people It differs in degree of violence, temperature, humidity, dryness, electricity, and ozone. The only point of agreement at different times when the wind blows is in its being a ground-current and thus carrying impurities in the air from many miles. A confirmation of this result is afforded by the fact that the South West wind is generally wholesome The North- East wind descends from the pole towards the equator and is close on the surface of the earth, whereas the South-West wind descends from the elevated regions of the atmosphere and is thus free from dust, effluvia, &c Here is agreement in being a ground-current in the case of the N-E wind, and agreement in not being a ground-current in the case of the S-W wind There are two sets of instances, *within the same range of facts*, for both winds have a certain temperature; electric charge, ozone, &c., and thus there are points of comparison and contrast Thus we have the following symbolic representation:—

The North-East wind
First set of Instances
Agreement in having A *a*

Antecedents
- A . being a ground current
- B violent
- C. .cold
- D ..wet
- E . feeble electric charge
- F . ..less ozone

Consequents
- *a* injurious
- *b* .felt stormy
- *c* .. ..felt cold
- *d* . felt wet
- *e* having a feeble electric charge
- *f* . . having less ozone.

Take other instances of the N-E wind and you will get A B C D E F, followed by *a b c d e f*, then, circumstances other than B,C,D,E,F, may sometimes accompany the wind, *e g*, rain and so on .

Similarly take the S-W wind. There too differences of all sorts in B, C, D, E, F and in other circumstances still will be found Yet *every time* A *a* will be *absent*.

Hence A *a* is a causal sequence.

(2) Wells' investigation into the formation of dew affords a nice illustration of the Joint Method of Agreement and Difference. The instances in which much dew is deposited agree in only one circumstance, namely, their radiating heat rapidly or conducting it slowly. In other respects they are quite dissimilar, e g, glass, roughened iron, especially if painted over, loose surfaces (cloth, wool, velvet, &c) are dissimilar in all respects save one, viz., the property of radiating heat rapidly, or conducting it slowly. Again, the instances which are not favourable to the formation of dew agree in *not having one and only one property*,

namely, that of radiating heat rapidly or conducting it slowly. Thus, polished metal, varnished paper, and stones are substances on which no dew, or but little dew is formed They differ in all respects save one, and that one is the absence of the property of radiating heat rapidly, or conducting it slowly. The property is absent in them uniformly Hence we have here *two sets of instances, positive and negative in the same range of facts*, the first set *having only one property in common*, the second *not having the same in common* Hence the property is the cause of the formation of dew

4 THE METHOD OF RESIDUES

14. THE STATEMENT AND EXPLANATION OF THE METHOD OF RESIDUES: Mill's statement of the canon of the Method is as follows:—

Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents and the residue of the phenomenon is the effect of the remaining antecedents.

On analysis, the following will be seen to be the conditions of the rule:—

(1) We should know by previous experience that a certain complex phenomenon is the effect of a certain complex set of antecedents

(2) certain component parts of this phenomenon are known to be due to certain causes,

then, what remains or the residue of the phenomenon, is due to the remaining part of the complex antecedent

If a total result is due to a certain number of antecedents, and part of it, to a portion of the antecedents, then the remaining part is due to the remaining antecedents.

This method is a *special* case of the Method of Difference, this will be evident by seeing how it is symbolically represented If *a b c* is the phenomenon to be investigated and its antecedent is A B C, then if we know that B is the cause of *b*, and C of *c*, what remains or the residue *a*, must have A as its cause. For we have

Antecedents			Consequents
	ABC	followed by	*abc*
But			
	B is	causally followed by	*b*
and	C is	"	*c*
	BC is	"	*bc*

Hence *a* must be the effect of A We perform as it were a mathematical subtraction here For, ABC is followed by *abc*, and by previous inductions we know that B C is followed by *b c* and that this latter sequence is causal. Hence, by subtraction, the part *a* of the consequent, is the effect of A, the remaining part of the antecedent

The canon of the Method of Residues assumes the phenomenon to be investigated as an effect, but a similar rule applies in the investigation of the phenomenon of a residuary cause.

The other symbolic representation would be

A B C is followed by *p q r*,

when

B C is " *q r* as its effect

A is the cause of *p*

The anomalies in the motions of Uranus led to the discovery of the planet Neptune The anomalies were not unaccounted for by the known causes, namely, the influence of the known planets Hence the residue which remained unaccounted for was inferentially imagined to be due to some unknown planet and the discovery of the planet

Neptune was one of the best triumphs of the application of the Method of Residues

We mainly apply the Method of Residues when we have a homogeneous intermixture of effects. Then the analysis is of a more complicated nature, the causes being homogeneous are not separately noticed, and hence, they have to be detected by a minute and almost a mathematical test A very simple illustration of this method is given by Jevons. We weigh the exact weight of a commodity in a cart by weighing the cart and load, and then subtracting the weight of the car alone Of course, this latter must be previously known. What remains or the difference is the weight of the load. We take a complex phenomenon and subduct the known cause and effect. What remains is the causal sequence to be discovered We have A B C—*a b c*; the cart and load producing a certain pressure (weight), then we create B C—*b c*, for we know previously the weight of the cart Therefore we find out A *a*.

The use of this method is "as a finger-post to the unexplained" Suppose a a person when submitting to medical examination tries to evade the true result His temperature might he 103°, but he is interested in deceiving the doctor, e g, to save being sent to the quarantine. On his face there might be signs of fever and his body might be very hot But the thermometer gives the reading 99°. How is it? The fever as it appears is higher than the same as noted This is unexplained The doctor tries to see whether the bulb of the thermometer touched the tender skin of the body. If he finds that this was not so, the bulb having touched only some part of the person's clothes, the fact is explained a cloth intervening the bulb and the skin *causes* the instrument to give a lower reading.

15 THE PECULIARITIES OF THIS METHOD: IS IT DEDUCTIVE OR INDUCTIVE?—The Method of Residues is specialy useful under certain circumstances Where a complex fact is for the most part explained, and there remains some excess or defect to be accounted for, a cause has to be found out for it If the known causes do not account for it, what is the inference? Evidently there is some residuary cause. If the excess or defect is explained away as being deducible from this residuary cause, we have established its reality. Is not the method then deductive? Deviations in the motions of Uranus were not explained by the known causes, namely, the influence of the known planets A residuary cause was therefore imagined, and its effect was deduced Then it was found that the *deviations deduced* were just the deviations found. Therefore, the agent imagined, namely, another planet (Neptune) influencing the motion of Uranus, was real This was found so by astronomical observation based on the prediction How, in this case, can the application of the rule be called inductive ? Strictly speaking, the Method of Residues is deductive. It finds a place in the list of the Inductive Methods, because it is useful in suggesting subsequent inductions, and is applied to the results of previous inductions Thus very often the unforeseen causes or effects of certain phenomena are suggested by this Method It is through its assistance that we pass from the known to the unknown. This is the justification of its inclusion in the list of the Methods The following quotation from Bain's "Inductive Logic"* will bear out the truth of this remark

* (p 66)

Sir G C. Lewis remarks that "the unforeseen effects of changes in legislation, or of improvements in the useful arts, may often be discerned by the Method of Residues. In comparing statistical accounts, for example, or other registers of facts, for a series of years, we perceive at a certain period an altered state of circumstances which is unexplained by the ordinary course of events, but which must have some causes For this *residuary phenomenon*, we seek an explanation until it is furnished by the incidental operation of some collateral cause For example on comparing the accounts of live cattle and sheep annually sold in Smithfield market for some years past, it appears that there is a large increase in cattle, while the sheep are nearly stationary. The consumption of meat in London may be presumed to have increased, at least in proportion to the increase of its population, and there is no reason for supposing that the consumption of beef has increased faster than that of mutton There is therefore, a residuary phenomenon, viz, the stationary numbers of the sheep sold in Smithfield, for which we have to find a cause This cause is the increased transport of *dead meat* to the metropolis, owing to steam navigation and railways, and the greater convenience of sending mutton than beef in a slaughtered state" The cause is suggested by the Method of Residues (and that is the justification of its discussion in a system of Inductive Methods)

16. THE METHOD OF RESIDUES AND THE METHOD OF DIFFERENCE —The Method of Residues is practically one case of the Method of Difference and has all the certainty of that Method The Method of Difference requires two instances, one having the occurrence of a phenomenon, and the other lacking this, other points being similar. It re-

quires instances of the type $\frac{A\ B\ C}{a\ b\ c}$, $\frac{B\ C}{b\ c}$. Given this, $\frac{A}{a}$, it is evident, is a causal sequence The Method of Residues starts with the partial knowledge that we have $\frac{B}{b}$, and $\frac{C}{c}$, then if we are given $\frac{A\ B\ C}{a\ b\ c}$, we can, taking the complex case $\frac{B\ C}{b\ c}$, infer that what remains is $\frac{A}{a}$, as a causal sequence The requirements of the Method of Difference are here *prepared* by us, and *not given* The Method of Difference like the Method of Agreement, and the Joint Method of Agreement and Difference has relation merely te *qualitative induction*, i. e , it is based on the simple fact of something happening or not The Method of Residues, however, is applicable under far more favourable circumstances, and deals with what may be called *quantitative induction* It is based not simply on qualitative but on quantitative data. Hence it acts under far more favourable circumstances, circumstances where every degree and quantity of a phenomenon give us fresh bases for the discovery of causation This is equally so in the Method of Concomitant Variations The Method of Residues is based on the simple calculation that the known causes are *not adequate to explain* the complex phenomena under investigation There is *more* in the effect, than can be accounted for from the causes. Hence the Method is *quantitative*, and therein it differs from the Method of Difference It is based chiefly on the *quantitative* aspect of causation, namely, that cause and effect are quantitatively equal, whereas the Method of Difference is based on the purely *qualitative* aspect Both the methods give certain

results, since the principle is the same, yet, the Method of Residues works under favourable circumstances, and unravels unexpected sequences which the other Method cannot do Evidently, the Method of Residues can come into operation only *when knowledge has considerably advanced* whereas this is not necessarily so in the other case. Once however, the facts are suitable to its application, it can solve very complicated cases unexpectedly and with the greatest possible certainty. Thus, the inference that there exists a planet besides the known planets, to account for all the deviations of Uranus, was made earlier than the actual discovery of Neptune Yet, look at the exultation of Sir John Herschell at the *prospect* of its discovery, which shows how powerful the Method of Residues is. He said. "We see it (the new planet) as Columbus saw America from the shores of Spain Its movements have been felt, trembling along the farreaching line of our analysis, with a certainty hardly inferior to that of ocular demonstration "*

ILLUSTRATIONS.

(1) Chemistry makes use of this method freely. Many of the new elements are discovered by testing residual phenomena Again, the proportional weights of substances are determined by this method. Thus, if we want to know the composition of water, an experiment may be performed on oxide of copper Hydrogen may be passed over a known quantity of oxide of copper in a heated tube The Oxygen and Hydrogen will form water Now the weight of the water formed may be known, and the original weight of the oxide of copper is known subtracting the final weight of the oxide of copper from the original weight, we get the

* (De Morgan's "Budget of Paradoxes," p 237)

weight of the Oxygen separated Then, by subtracting the weight of the Oxygen from the weight of the water thus formed, we get the remaining, as the weight of Hydrogen combined *

(2) Astronomy affords many examples of the applicability of this method, for the evident reason that the science is deductive and mathematical. A simple example, namely the discovery of Neptune, is already discussed by us

(3) The Method of Residues is freely used in Political Economy Will a particular taxation account for the whole of the miseries and complaints in a state? If exports and imports are equal, how is it that in a particular case this is not so? Questions like these force the discovery of residual phenomena Even in the sciences which are non-statistical, this method is at times made use of Thus, some questions in Psychology and Moral Philosophy are solved on the basis of this Method. Are we conscious automata or mere living machines ? Many of our psychical actions are explained on the assumption that we are mere machines But what of the few that remain? How shall we account for our *selective* actions ? Has our will no efficacy ? If it has it not, we are automata But it *has* an efficacy, here is a residual phenomenon, and we must account for it, which we can do by adding something to the machinery, and thus rejecting the automaton theory There are some questions similarly solved in Moral Philosophy too

---

5 THE METHOD OF CONCOMITANT VARIATIONS

17 The Statement and Explanation of the Method of Concomitant Variations —Mill states the canon of this Method thus —

* (Dr Roscoe's "Lessons in Elementary Chemistry," p 38)

"*Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation.*"

The rule may be analysed as under:—

(1) If there are variations in two phenomena, and
(2) the variations in the one follow those in the other,

then, the two phenomena are connected as cause and effect, (or are at least connected through some fact of causation, i e, they are co effects).

Symbolically we may argue thus:—

Antecedents		Consequents
A' B C	followed by	*a' b c*
A" D E	"	*a" d e*
A"' F G	"	*a"' f g.*

Here we have two or more instances in which a variation in A is followed by a variation in *a*, other circumstances also varying. We have *agreement in the increment* of the phenomenon A *a* It is clear from this that the Method of Concomitant Variations when thus represented is a *special case of the Method of Agreement* In the Method of agreement we have A *a* all along, the B C D E F G, *b c d e f g* .. are different if we pass from one instance to another. The concomitants of the phenomenon under investigation change in the two or more instances in the Method of Ageement; so too do they, here, i. e. in this symbolic representation. There is *agreement only in the increment* of A*a*. Thus this is just like the Method of Agreement. In that method *the phenomenon under investigation is uniformly present* in the different instances, here the *variation* (increment or it may be decrement all along) *in the phenomenon is uniformly present* in the different instances.

In the above case, Aa is a causal sequence or if A is not the cause of a, at any rate A and a are connected through some fact of causation

If we take the Method of Concomitant Variations as a special case of the Method of Agreement, it is liable to be frustrated by a plurality of causes just as the Method of Agreement is so For, we take $\frac{A'\ B\ C}{a'\ b\ c}$, $\frac{A''\ D\ E}{a''\ d\ e}$, and $\frac{A'''\ F\ G}{a'''\ f\ g}$. Here we argue that A is the cause of a from the fact of uniform variation. But it may be that D or E may be the cause of a' becoming a'', and F or G may be the cause of a "becoming a'''" Thus suppose in two or more successive years there is famine, and that scarcity increases more and more Together with it we may notice in the case supposed, say increase in thefts Thus we have more of scarcity, more thefts We have A' a', A'' a'', A''' a'''. Does it follow that scarcity is the cause of the increase of of thefts ? The other concomitants in the symbolic representation of the Method of Variations thus explained, vary, and therefore, B, C, D, E, F, G must also change Suppose then that the concomitants of scarcity change in the successive years. Suppose in the first year we have scarcity accompanied with specially weak police, and that in the second, we have it accompanied with a special inrush of hill tribes from neighbouring countries Then, it may be that thefts may be due in one instance to the weakness of the police, and in the other, to inrush of hill tribes, and that the criminal tendency of the famine-affected people may not have increased at all That is, famine has no causal connection with the thefts If the other circumstances, then, change, the phenomena which vary may not be

causally connected. Plurality of causes vitiates this method just as it does the Method of Agreement

Or it may turn out that just as in the Method of Agreement, some other circumstance may be the common cause of the variation Thus, the hour-hand and the minute-hand of a watch vary concomitantly Yet the variation of the one does not depend on that of the other, since it depends on the machinery of the watch. The machinery is the cause of the co effects, namely, the concomitant variations of the two hands The two variations are connected through a fact of causation but are not cause and effect *

The Method of Concomitant Variations may also be taken as a special case of the Method of Difference and this is its more important case The Method of Difference requires that there are two cases differing only in the presence or absence of one circumstance, in other respects the cases are similar, i e, *the concomitants of the phenomenon are the same* Now this Method cannot be useful in certain cases, e. g, where we have to deal with forces like heat, gravity, cohesion &c, which cannot be (absolutely) eliminated. We *cannot get the instances of the absence* of these phenomena. We can then make use of the Method of Concomitant Variations, for though we cannot get any instance of the absence of heat, gravity, &c, we can get instances of the *absence of some quantity of* heat, gravity, &c We may obtain a *negative instance of a given quantity* of such phenomena Thus the following symbolic representation will speak for itself:—

* We decide that this is not a case of causation by saying and observing that the movement of the minute-hand is not *unconditionally* dependent on the movement of the hour-hand, and *vice versa*. We may eliminate the one movement and yet the other remains: hence the one is not the cause of the other

Antecedents		Consequents
10 A B C	followed by	10 $a\ b\ c$
20 A B C	„	20 $a\ b\ c$
100 A B C	„	100 $a\ b\ c$
or		
A' B C	„	$a'\ b\ c$
A'' B C	„	$a''\ b\ e$
A''' B C	„	$a'''\ b\ c$

Here *only* the phenomenon A' a' varies, the concomitants remain the same, and if we pass from A' a' to A'' a'' we get a certain quantity changed into a certain other quantity. The phenomenon does not disappear as in $\frac{A\ B\ C}{a\ b\ c}$ and $\frac{B\ C}{b\ c}$ but *a certain quantity of the phenomenon disappears* (varies) Hence this is a special case of the Method of Difference The result also is as certain here as in that method Suppose we have a certain friction applied to a certain body, and a certain quantity (degree)of heat results. increase the friction, the heat increases, i e, its degree increases The body is the same, therefore, the concomitants of the phenomenon $\frac{\text{friction}}{\text{heat}}$ or $\frac{A}{a}$ remain the same, only there is more friction, more of heat Friction and heat cannot completely disappear from any earthly body. Therefore, we take more or less of these phenomena and notice that there is uniform variation Hence, friction we infer to be the cause of heat, friction is not the effect of heat, because there is no such consequence and antecedence, only heat follows friction, not *vice versa*, Moreover, there is *loss of energy* from the body to which friction is applied, and not from the substance heated.

If the conditions of the Method of Difference are satisfied, e g., if there is only a variation in the phenomenon under investigation and no other concomitant circumstance changes, we may infer causation with certainty. Thus, if the same body in the same set of conditions has more or less of heat accordingly as friction increases or decreases, there can be only one conclusion, namely, that friction produces heat. There is no possibility of there being a frustration of the method by a plurality of causes, because no other circumstance has changed, and as in the Method of Difference, the results in this Method too are certain.

The Method of Concomitant Variations, like the other Method may be represented by symbols having no suggestions Thus

I. The Method, as a special case of the Method of Agreement would be—

Antecedents		Consequents
A' B C	followed by	*p' q r*
A'' D E	,,	*p'' s t*
A''' F G	,,	*p''' u v*

II The Method treated as a special case of the Method of Difference:—

Antecedents		Consequents
A' B C	followed by	*p' q r*
A'' B C	,,	*p'' q r*
A''' B C	,,	*p''' q r*

A simple illustration of the Method of Concomitant Variations in its perfect form (i e, when it is treated as a special case of the Method of Difference, i e, when the concomitant circumstances of the varying phenomenon remain the same), would be the experiment to prove that air is the cause of transmission of sound. Strike a bell in a vacum in a receiver. no sound is heard Strike it in the same receiver

with air sound will be heard Here we have an application of the Method of Difference, for in the receiver no other change has occurred In the same case, let a very little air be introduced in the receiver then a faint sound will be heard, add more air, and the sound will increase Here we have a case having more or less of air (*other circumstances remaining the same*), therefore, it follows that air is the cause of the transmission of sound

18. THE PECULIARITIES OF THE METHOD AND ITS SPECIAL APPLICATION:—The Method of Concomitant Variations is useful where the causes or effects under investigation cannot be eliminated, but can be studied only in their increase or decrease Such are heat, gravity, friction, cohesion, &c The Method is a modification of either the Method of Agreement, or the Method of Difference and is accordingly liable to frustration as the former Method is, or not so, as the latter

---

ILLUSTRATIONS

(1) Mill gives a simple example of the application of the method with reference to the doctrine of inertia In ordinary circumstances the oscillation of a weight suspended from a fixed point and moved a little out of the perpendicular lasts but a few minutes In Borda's experiments this was prolonged to more than thirty hours, by diminishing the friction at the point of suspension, and by suspending the body in a space exhausted as nearly as possible of its air The retardation of motion was therefore evidently due to the friction, and the resistance of air Subducting the retardation from the total phenomenon the remainder was uniform motion This is what is known as the first law of motion Here, evidently, we have

method which is a modification of the Method of Difference, and the result is therefore certain.

(2) Fowler gives an interesting illustration from Physiology. In this science we seldom get a phenomenon present in one set of instances and entirely absent in another. Hence the Method of Concomitant Variations is the only Method which is applicable We have only to establish causation from Concomitant Variations As an example he takes the case of the relation between the development of intelligence and that of the brain No human being is entirely lacking in intelligence and brain The relation between these two has therefore to be studied by the Method of Variations It appears that the development of the cerebrum and the degree of intelligence vary uniformly By the cerebrum is to be understood not only bulk of brain, but also the complexity and depth of the nerves and tissue of the same. Dr Carpenter, whom Fowler quotes, says as under

"It may be doubted if two individuals were ever exactly alike in this respect That a cerebrum which is greatly under the average size is incapable of performing its proper functions, and that the possessor of it must necessarily be more or less idiotic, there can be no reasonable doubt On the other hand, that a large, well developed cerebrum is found to exist in persons who have made themselves conspicuous in the world in virtue of their intellectual achievements, may be stated as a proposition of equal generality "*

Further, according to Dr. Thurman, the average brain-weights of some ten distinguished men who died between the ages of fifty and seventy was 54 7 ounces each. The average weight in the case of ordinary men dying at the same age, however, is according to him 47 1 ounces This

* (Principles of Human Physiology, quoted by *Prof* Fowler)

calculation supports the remark of Dr. Carpenter, and gives an excess of 7 6 ounces of weight (15 p c) in favour of distinguished men. Thus the general rule is safe that cerebral and intellectual development are causally connected. Of course, no particular conclusions can be drawn from this, for an undue enlargement of the brain in a diseased condition is also possible, and there is a recognised brain-disease of this type Such a pathological or diseased enlargement of the brain is attended with idiocy. It forms an exception to the rule seen to be based on the Method of Concomitant Variations

SHORT SUMMARY OF RESULTS

The Methods of Induction may be best remembered by keeping in mind the symbolic formulæ representing the different canons

The Method of Agreement—

A B C— *a b c*, A B D— *a b d*,

A— *a* are probably cause and effect, or are connected through some fact of causation

The Method of Difference—

A B C—*a b c*, B C—*b c*,

∴ A— *a* is a causal sequence

The Joint Method of Agreement and Difference—

A B C—*a b c*, A B D—*a b d*,

B F G—*b f g* , DHI,—*d h i*, and so on;

∴ A—*a* is probably a causal sequence.

The Method of Residues—

If B– *b*, C–*c* are known previously to be causal sequences, then, given A B C—*a b c*, it can be inferred that A–*a* is also a causal sequence.

The Method of Concomitant Variations—

(1) A' B C—*a'* *b* *c*, A" D E—*a"* *d* *e*, and so on;
.. A—*a* are probably cause and effect, or are connected through a fact of causation
or (2) A' B C—*a'* *b* *c*, A" B C—*a"* *b* *c*, and so on;
.. A—*a* is a causal sequence.

Case (1) is a special case of the Method in accordance with the Method of Agreement, whereas case (2) is a modified form of the Method of Difference

It will be noticed that strictly speaking there are only two Inductive Methods -(1) The Method of Agreement, and (2) the Method of Difference The Joint Method of Agreement and Difference is a method of Double Agreement, and like it can give a conclusion only of more or less probability The Method of Difference and its special cases, the Method of Residues and that of Concomitant Variations can arive at cartain results. The Joint Method has one point of superiority to all the other Methods, namely, that it alone can prove something as the *only* cause of some effect, the reason of this is that, provided the positive and and negative instances are numerous, wa prove that *whenever* a particular antecedent is present, a particular consequent occurs, and *whenever* it is not, the consequent does not occur, the latter half of the proof shutting out the possibility of there being any other cause. If there is any other cause, it may occur in one or other of the numerous negative instances (i e., of the absence of A) and may produce the effect (*a*), but the instances show that *a* is never seen in the absence of A Therefore, the cause proved by the Method is the *only cause* in the phenomenon investigated No other Method affords such a proof, because no other Method proves invariable agreement (in absence), of the antecedent and the consequent.

NOTE I.—A POSITIVE INSTANCE AND A NEGATIVE INSTANCE.—By a positive instance is meant an instance of the presence of a phenomenon, an instance of the presence of a supposable cause. For example, if two or more patients go to a particular doctor and they are cured of a particular disease, these are positive instances of the doctor's skill being a supposable cause of the cure.

By a negative instance is meant an instance of the absence of a phenomenon, an instance in which the supposable causal agent is not present and still the effect happens. To disprove, in the above example, that these cures were effected by a patent medicine used by the doctor, we must have negative instances, i.e., instances in which the patent medicine was not used and still the particular disease was cured in the case of other men by the treatment of the same doctor. If we have two instances A B C—*p q r*, A D E—*p s t*, we can say that the second instance is a negative instance of B or C as supposable causes of *p*, or that the first is a negative instance of D or E as the supposable causes of *p*.

conclusive according to some logicians when we can deductively support the causal relation of the antecedent and consequent in question The remaining two Methods are special cases of the Method of Difference, and of the two, the conclusiveness of the Method of Residues is due to its being deductive There is more of deduction than induction in the Method of Residues Hence their claims as Methods of proof are not as solid as Mill maintains Some of them are evidently deductive, and there are deductive bases in all of them, for both the Methods, the Method of Agreement, and that of Difference are based on *elimination, which is impossible without deduction.* Despite all this, the Inductive Methods have won general acceptance, chiefly because they are the Methods of rationalising all knowledge based on experience

Note 3 THE ART OF DISCOVERY —The Inductive Methods are treated by Mill as Methods of Proof They enable us to test Inductive Generalisation Indirectly, they enable us to discover laws and the explanations of things The question, How are laws discovered? is very insteresting, but too general for being handled in this treatise It may be solved in an elementary way, and then the connection between Discovery and Proof will be seen to be a close one

There are Logical as well as Psychological aids to the discovery of laws The latter may be simply mentioned and the former explained in detail here

Discovery implies the observation of a large number of facts and reasoning carried on with reference to the same Now the power to strike out identities in facts can be cultivated only to a very limited extent, for there are no common-place rules for the same Some men are pre eminently fitted for scientific discoveries Their minds are as it were suited to nature If, however, we analyse the condition of discovery we may note that the mind should have a large store of facts, that it should not be overpowered with specialities and with observation only, that it should make frequent comparisons and analogies, and that it should look upon the same facts again and again under different aspects These are some of the psychological aids to discovery

In the logical aids to discovery it is needless here to note the help given by habits of analysis in Formal or Deductive Logic The

Equivalent Propositional forms and syllogisms are highly suggestive of new connections between phenomena

The Inductive Methods directly as well as indirectly aid Discovery The Method of Agreement is very serviceable, because we collect all instances agreeing in one circumstance This in itself is highly suggestive of a law undiscovered For, if at all there is a law it must govern like facts in a like manner This is the reason why the Method of Agreement suggets discovery Additional help is given to this Method when we look to Agreement in absence as well as in presence The Method of Difference is simply a Method of Proof The Method of Residues, however, is specially fitted for Discoveries It enables us to see unexpected laws and find out causations in the midst of complex facts The Method of Concomitant Variations is also directly suggestive of Discovery, for the variations force themselves on the mind, and when the collection of instances is sufficiently large, laws may be easily discovered by this Method.

The processes subsidiary to Induction are directly suggestive of Discovery It is the function of a hypothesis to explain facts, and thereby to discover laws The processes of Observation and Experiment are the indispensable causes of Discovery, because without collecting a large number of suitable facts no attempt at explanation can be made Classification, Nomenclature, and Terminology are processes best suited for recollection and reference, and as such serve a useful antidote to confused thinking, which is the greatest obstruction to explanation

Note 4 –FRUSTRATION OF THE INDUCTIVE METHODS –This subject is in passing dealt with in this chapter In the note we shall discuss it in detail The Inductive Methods as simply explained, took for granted two conditions (*1*) that an effect has only one cause and (2) that different effects are separate and remain unmixed Thus we say A B C is followed by *a b c* Here we assume A to be the cause and the only cause of *a* and *abc* the effects to remain separate when as a matter of fact in nature we sometimes find effects like *2 a c*, or *2a b*, or 3 *a* instead of *a b c* The first is the case of Plurality of Causes, the second, of Intermixture of Effects The first, is illustrated by showing death to be an effect which may be due to suicide, disease, murder, accident, &c motion an effect due to wind, water, electricity, physi-

supposed For, if there was any other cause, it must have come into constant operation If this did not happen and the multiplication of instances showed one circumstance as prominent and uniform, then we are justified in inferring causation

The other means of avoiding the frustration of the Method of Agreement by a plurality of causes is the application of the Joint Method We must seek cases of Agreement in *absence* Suppose the death rate in a particular locality in a city is very high and that it is not so in any other locality Now death may be due to diseases due to natural causes like old age, infirmity &c, or impurities of the air, or accidents and so on In the affected locality we find one prominent circumstance, namely, impure air and in the remaining localities this very circumstance is found absent When this is so the death rate has a causal connection with the impurity of air in the affected locality Although there are various causes of death yet the union in presence and in agreement of this one antecedent makes it almost certain that it is the cause of the high rate of mortality investigated This certainty grows out of the fact that the Joint Method approximates to the Method of Difference, which remains unaffected by a Plurality of causes If we get two cases exactly similar and differing only in the presence or absence of one set of antecedents and consequents we are quite sure that in this case the two are causally connected, that there may be other causes for the same effect, does not affect the case under investigation

The Intermixture of Effects creates insuperable difficulties in the application of the Inductive Methods *It prevents elimination* Thus if A B C produce 2 a c, or A B C produce $a + \frac{1}{2}a - \frac{1}{2}a$, or $\frac{a}{2}$ c, how can we assign the part due to A, B, and C? Cases of the kind arise wherever the effects of several causes are homogeneous, e g two men pulling at the same rope in the same or different directions Further, we may have cases of the *mutuality* of cause and effect, and this may produce Intermixture of Effects Thus with civilization education advances and this enhances progress of civilization Industry may produce wealth, and with wealth industry may increase In cases of this type it is very difficult to determine the causes of any effect The Method of Agreement will be quite useless For we

already discussed the case of saving Two men may have a saving of Rs 1000 at the end of a year Does it follow that their income, or expense is the same? Decidedly not The Method of Difference will be useful only when the effects and causes can be quantitatively measured Then we may apply the Method of Residues or the Method of Concomitant Variations The latter is the Method most serviceable in complicated cases of the intermixture of effects Thus if the appetite for food increases *only with* the taking of a peculiar tonic this is a sure sign of the efficacy of the same We must try it in different climates constitutions, moods and so on, and yet if the result remains the same, the tonic is proved to be efficacious It is the Method of Concomitant Variations which enables us to find the respective parts of the sun and the moon in the action of the tides—a complicated case of intermixture of effects Similarly many political and economic problems are difficult to solve because of the complication due to intermixture of effects Thus rise in the price of food-stuffs may be the phenomenon to be investigated Many effects combine in this case Yet if we find that statistics prove that the rise in prices varies with the increment of exports the latter would undoubtedly be the main cause of the effect

mood, and other accompanying circumstances, we naturally conclude that the food causes the illness We exclude climate, mood, temperature, other food or drink, &c, &c, because they are different in the two or more cases There is only one thing in which there is agreement, namely, the food in question We *exclude* or *eliminate* the other circumstances and hence feel justified in arriving at the conclusion Hence the Method is a Method of Elimination (Remember that all the Methods are Methods of Elimination) Now, *in Simple Enumeration we do not make use of the process of elimination but simply collect like cases* The conclusion in Simple Enumeration is based not on *elimination*, but merely on the *number* of instances Thus the statement "All Frenchmen are social would be a case of Simple Enumeration if based on uncontradicted experience of sociality in the case of some Frenchmen with whom we came into touch The more the instances, the more solid the basis of the assertion Even then the result depends only on an *accumulation* of instances, whereas in the Method of Agreement we do not simply *accumulate* instances, but rather *select* them For this reson a few well selected instances often satisfy the conditions of the Method of Agreement, and will give us a more reliable conclusion than the same number or even more when we abstract the grounds on which they were selected

---

QUESTIONS

(1) State and explain the Method of Agreement

(2) What is elimination? How is it necessary in the Methods of Induction?

(3) Distinguish the Method of Difference from
  (a) the Method of Agreement,
  (b) the Method of Agreement and Difference,
  (c) the Method of Residues,
  (d) the Method of Concomitant Variations

(4) Show that the Method of Residues is deductive
  How is it included in the Inductive Methods?

(5) What can you infer from the following instance, and why

Antecedents	Consequents
A B F	*p q w*
B D E	*q s u*
A D E F	*p s w u*
B H K	*q v x*
A B C	*p q r*
B C D	*r q s*

(6) Show how the Method of Concomitant Variations is a special case of (a) the Method of Agreement, and (b) the Method of Difference

(7) Supposing you want to find out the causes of the following phenomena, how will you proceed? State the name of the Methods you will use, and show whether you will succeed in ascertaining the causes —

(a) The connection between flashes of lightning and peals of thunder

(*b*) The connection between the Thermometer and fever

(*c*) The connection between widowhood in India and the custom of early marriage

(8) How does the Method of Agreement differ from simple enumeration? How is the Method liable to be frustrated by a plurality of causes. Is there any means to avoid this kind of frustration?

(9) Give two instances each, of the use of each of the Inductive Methods Show with symbolic representation how your instances are illustrative of the different Methods

(10) Show how the inductive Methods are dependent on elimination Explain what is meant by saying that they are "weapons of elimination"

(11) What conclusions do you draw in the following cases, and by what methods?

(*a*) A bell gives no sound in the exhausted receiver of an air-pump, but it does give a sound, when there is air in the receiver

(b) More of food, more of physical strength, but sometimes the result is disease

(c) During the last few years the Railway lines have greatly increased, and the internal trade of India has also greatly increased

(d) During the last few years eduction in India has increased and the custom of early marriages decreased

(12) (1) Friction alters the temperature of the bodies rubbed together

(2) The sun is supposed to move through space

(3) A ray of light passing into or out of a denser medium is deflected

Point out the successive quesions which would have to be decided in the investigation of the above phenomena [Jevons]

(13) What is meant by Intermixture of Effects? How does it render the applicability of the Inductive Methods a matter of very great difficulty?

(14) What principle is appealed to here?—

A different cause,' says Doctor Sly
The same effect may give
Poor Lubin weeps lest he should die,
His wife, lest he should live Prior [Stock]

(15) What Inductive Methods are employed in the following? Show how and test the application of the method in each case

(a) Wealth causes Christianity, for the wealthiest nations are Christian [Stock]

(b) In reply to my question about the purpoise-grease with which his body was anointed Captain Webb informed me that he did not know that it helped him at all However of course this point could only be settled by the direct experience of a swimmer performing a feat under exactly similar conditions both with and without the oil *Daily News*, Sept 17 1875 [Stock]

(c) All the institutions managed by Mr X were well-managed, while not one institution managed by his contempdraries thrived X and X alone, therefore, was a successful head.

(d) X, a new doctor begins practice in Bombay He cures all the cases of a particular disease under his treatment, and no other doctor there does so People, therefore, put faith in him

(16) Illustrate the different Inductive Methods from your own experience of student-life.

(17) Describe the *logical characters* of the following arguments and *test* their *validity* —

(a) Change in the temperature of a body is always accompanied by a change in its volume Therefore expansion is the cause of heat

(b) The advent of a comet thrice was found accompanied with political disturbances The third time it was approaching the earth, grave fears were entertained

(c) "Sir D Brewster proved that the colours seen upon mother-of-pearl are not caused by the nature of the substance, but by the form of the surface He took impressions of mother-of-pearl in wax, and found that, though the substance was entirely different the colours were exactly the same" [Jevons]

CHAPTER VIII

COMBINED INDUCTION AND DEDUCTION

1 INTERDEPENDENCE OF THE INDUCTIVE AND DEDUCTIVE METHODS —The two Methods, Inductive and Deductive are not entirely separate and independent. In fact though we have spoken of the Inductive Methods as such, yet, as a matter of fact, the logic applied in using them is of a deductive character The Inductive Methods simply summarise the conditions under which causal relations may be asserted. In their application to a particular case, we must make use of deductive logic Thus we have the follwing as the analysis of what we do:—

Whatever relation of events has certain marks (sequence, immediate, invariable, unconditional) is a case of causation,

The relation A a has some or all of these marks (as shown by the application of the Methods to the data of Observation or Experiment)

∴ The relation A a is a case of causation.

This argument is further analyseable, for the minor premiss has a certain reason to support it

If two or more instances of the phenomenon &c, &c (canon of the Method of Agreement):

The instances $\frac{A\ B\ C}{a\ b\ c}$, $\frac{A\ B\ D}{a\ b\ d}$ ..are of this kind

∴ A, in which alone the instances agree, is the cause of a

This shows that the formal logic of Induction is deductive The reasoning involved in the Methods being deductive in this way, the interdependence of the Inductive and Deductive Methods is easy to see.

But there is something more than this. The inter dependence above shown is yet superficial We are never satisfied with detached inductions or empirical generalisations We want to unify knowledge Laws like the Law of Gravity, the Conservation of energy, the Theory of Natural Selections are grand unifications of the different laws which apply under different conditions Assuming our minor generalisations to be true and interdependent, we form a general principle under which they all stand If this principle is supported by facts or verified to be true we accept it as a grand generalisation Induction, Deduction, Verification are the three processes with the help of which unification of knowlege is rendered possible Induction, thus does not stand aloof, but must take the help of Deduction, if progress in knowledge has to be achieved

2 THE DEDUCTIVE METHOD.—This Method has three steps, and it consists in the alternate use of induction and

deduction Mill call it the Direct Deductive, or Physical Method. Its steps are as under:—

1. Induction.
2. Deduction or Ratiocination
3 Verification

When very complex phenomena have to be investigated the inquirer would consider, firstly, what laws already established by *induction* are likely to apply to the case, secondly, what are the likely effects *deducible* from these laws in the case before him, and thirdly, are the effects thus deduced *verified* by facts, i. e, is his conclusion thus arrived at, borne out by facts: if so the law assumed is true We appeal to experience twice in this Method First, we have a rough and simple appeal, and finally, we have a verification from experience The intermediate process is ratiocinative or deductive. Thus, Newton passed a ray of sun-light through a glass-prism and found that it spread out into a series of colours resembling those noticed in the rain-bow. From this he made a rough *induction* that white light was a mixture of different lights which become separated in passing through the prism If however this is true *what would follow?* This can be known by *deduction.* If the induction is true, then, if one were to pass an isolated ray of the spectrum (e g, yellow) through a *second* prism, it ought not to again break up into different colours. It must remain as it is (yellow), for, it is, according to the rough induction simple Now as a matter of fact *experiment verifies* this the conditions of the Physical or Deductive Method are therefore fulfilled

Take another and a simple illustration of the way in which the Deductive Method is serviceable Supposing we know that solids and liquids gravitate Shall we apply the law of gravitation from these to an adjacent case, namely,

gases ? Do they gravitate ? This may be known deductively. Solids and liquids gravitate because they have one property in common, namely, they are matter If gases are matter, they must gravitate This is deduction Now the defining property of matter is inertia, and gases have inertia, therefore they gravitate Whether this is so may be verified by the process of observation or experiment In this way, the Deductive Method is applied It enables us in this case to extend the inductive law of gravitation (known to hold good of solids and liquids) to a new case (glass, adjacent to the two other cases)

A very common interlacing of the two methods—inductive and deductive—is noticeable in the framing of hypotheses All hypotheses are suggested by rough inductions e g , by simple enumeration or analogy as we noticed. After being framed they are tested. This requires that we should proceed to trace the consequences which would follow from the truth of our hypotheses This is ratiocination or deduction If facts agree, or other inductions agree (Consilience of Inductions) with them, we have verification and our hypotheses are to be accepted as valid

Combination of Inductive with Deductive reasoning is noticeable in the explanation of many of the complicated facts in Mechanics, Astronomy, Chemistry, and other exact sciences where from knowledge of simple laws we can deduce very complex phenomena, the sciences being mathematical

The Method is very serviceable in the Physical sciences, and hence it is also called the Physical Method

3 The Inverse deductive or Historical Method — In the Deductive (Direct Deductive or Physical Method) Induction was called to the aid of Deduction and the steps

were Induction, Deduction, and Verification (by Induction or Experience). When, however, the facts are too complicated to allow us to form a deduction to start with, we make use of another and just the opposite Method. In it, too we combine Induction and Deduction but differently. We at once form an induction and then show how from the nature of the case the same was to be naturally expected. In other words we *here verify the induction by deductive reasoning* Hence this Method is styled the Inverse Deductive Method The processes of the two Methods may be enumerated thus.—

In the Direct Deductive Method, we have,

(1) Induction,

(2) Deduction,

and then (3)Verification (by facts or other inductions)

In the Inverse Deductive Method, we have

(1)Induction, or Empirical Generalisation,

and then(2) Verification by Deduction.

The Inverse Deductive Method is also called the Historical Method for the reason that it is more useful than any other in the explanation of historical facts Examples of this method, coming as they do from historical and political literature will easily occur Thus to take an empirical generalisation, we say " History is biography " Why? We cannot at once begin with ratiocination in determining the prominent features of history We notice, however, that the lives of powerful men change the flow of events and leave a peculiar impress on the events of their times. Hence we are tempted to generalise that history is biography Having made this generalisation we try to verify the same deductively This we can do by seeing how much is to be expected from men of exceptional powers, rather

than from general causes determining events When we verify the generalisation in this way, we find that it is true only under certain conditions For whenever an empirical law has to be verified deductively, we should take into consideration (1) all the important conditions, (2) give weight to each of them in proportion to their importance and (3) should never take into consideration any condition which we cannot show to be probably present and operative. Now the progress of events is bound to depend on the force of personalities But the question is how far is man, the master of situation ? How much of importance should be attached to chance ? How many factors in events are beyond human control ? When such questions are raised and answered, we naturally attach less weight to the force of personality in the determination of events Then we see the conditions under which the generalisation is true.

As a rule historical events depend on innumerable causes, on the mode of government, religious, political, and educational institutions, customs, and habits, and their progress, the manners of the people, development of industries, science, art and literature and their progress, physical conditions of climate and geographical position, relations with other states, and so on It would be absolutely impossible to arrive at correct inductions in history Whatever inductions are asserted by historians are bound to be rough and empirical For this reason, if we can support our generalisations in history by a deductive basis and show that from the very nature of the case, certain events and results could have been deduced or anticipated and see that these are just the events explained by our inductions, we have a verification of the same by deduction.

Note THE MEANING OF VERIFICATION —While speaking of the Deductive Method we mentioned the process of Verification. The word Verification is used in more than one sense.

Firstly, by Verification is meant the process of testing by an appeal to facts conclusions previously arrived at by deductive reasoning Thus, it was deductively established that if an isolated ray of the spectrum were passed through a second prism it ought not to break into different colours, and this was actually borne out by facts, and therefore, the theory that white light is a mixture of different lights was correct.

Secondly, there is a looser sense of verification We sometimes use the word for the process in which any kind of appeal to facts is made. In the first sense, we understand by verification a process of appeal to facts, being a stage in the Deductive Method. In the second or looser sense, we mean by Verification any process in which an appeal to facts is made. Thus the performing of an experiment in order to test a hypothesis would be a verification. The retardation of Encke's comet is a verification according to some astronomers, of the theory that space is filled with some matter which produces this retardation

Thirdly we mean by Verification any corroboration of one law by another or one proof by another proof It means bringing one generalisation under another supporting inductions deductively. This mode of Verification is briefly explained in this chapter under the head of the Historical or Inverse Deductive Method. According to the Historical Method the generalisations or inductions in history are supported by a ratiocination from human nature in general Thus there is the rough generalisation "that at certain epochs great men occur in groups" It is an induction based on simple enumeration, for we simply look to the times of Elizabeth, George III, Akbar, and so on The generalisation is evidently based on insufficient evidence. But we can verify it to a certain extent from studies in human nature, e g, how intelligence is developed by competition, by society, and so on

---

QUESTIONS

(1) Show that the formal character of Inductive Logic is Deductive -

(2) What is the Meaning of the Deductive Method? How would you show the interdependence of Induction and Deduction?
(3) What is the Historical Method? Distinguish it from the Deductive Method
(4) What is Verification
(5) How would you establish the truth of the statement—'History repeats itself'

CHAPTER IX

LAWS PRIMARY AND SECONDARY

1 LAWS CLASSIFIED —Laws may be classified acordingly as they are more or less general

First, we have Axioms They are real, universal, self-evident propositions They are real as distinguished from verbal propositions of universal applicability to the phenomena to which they apply and resting upon their own evidence The Laws of Thought for example are axioms They are applicable to all thinking inasmuch as it is to be ideal thinking, they are real, and it is not possible to derive them from any other laws

Next to Axioms, we have the Primary Laws of Nature. They are of less generality than the axioms, and differ from axioms chiefly inasmuch as than admit of proof. They are not self-evident like Axioms. As examples of the Primary Laws of Nature, we have the Law of Gravity, the Law of Conservation of Energy, the Law of Heredity, &c They are all universal, yet they are less general than the Axioms The Law of Heredity applies only to cetain physiological and intellectual traits in Biology In that limited sphere the Law has universal application But the Axioms have a far wider application, for they are all-comprehensive, and even the formal evidence of the Primary Laws must depend on the Logical Axioms for proof.

Next we get the Secondary Laws. They are less general than the Primary Laws. They are either Derivative, or Empirical.

Derivative Laws are those Secondary Laws which have been resolved into, and are deducible from Primary Laws. Thus the laws of planetary motion are derivative, we can deduce them from the centrifugal and centripetal forces The Theorems of Euclid are Derivative Laws, since they can be deduced from certain geometrical axioms and ultimate laws of relations

Empirical laws are those secondary laws which are not deducible from any higher laws. Evidently, they have a less generality than the above laws As illustrative of these laws we may take the generalization that quinine is a cure for ague This law depends purely on empirical generalisation. It has not yet been shown to depend on any higher biological or botanical laws Scarlet flowers have no scent—is an empirical law of co-existence It is not deducible from any higher generalisation. All the laws of chemical combination are empirical, and so of most generalisations in Botany and Biology.

Empirical laws are of various kinds Bain describes three kinds

I Many Empirical Laws are made up of combinations of higher uniformities under certain collocations. We can see this only after these empirical laws are made derivative. Thus the laws of wind and rain are empirical laws. Yet we have resolved the laws of rain into certain derivative laws, e g, those dependent on humidity, and so on. From a knowledge of monsoon currents, moisture, high and low temperature, &c, the laws of rain may be deduced.

II Some secondary laws are laws of succession between effects and *remote* causes. Here too we know this after

we have resolved emprical into derivative laws. Thus a sudden shower of rain disperses a crowd The shower here is a *remote* cause, for the cause of dispersion is being wet, or the clothes being spoiled, this being repellent to the mind, and the mind becoming active and governing and setting in motion a certain nervo-muscular machinary So, the sowing of a seed is followed by the maturing of an oak Here too there are many intermediate links The result depends on suitable combinations of intermediate links.

III Thirdly, between the effects of the same cause there are some laws of Co-existence or Succession Thus the colours of animals depend on certain laws of natural selection From this we can deduce them So, we have the succession of day and night It is an empirical one, now deduced from other laws, day and night being as we know only co effects of the same cause So long as the causes of such co-existences and sequences remain unaffected, the co existences and sequences too remain as such

Looking to the constancy of generalisations, we can divide all secondary laws into (1) Invariable Secondary Laws, and (2) Approximate Generalisations The Laws of Planetary Motion are Invariable Secondary Laws, Secondary Laws, because we can deduce them from the mode of operation of centrifugal and centripetal forces, and Invariable Laws, because there are no exceptions to them in the Astronomical science Approximate Generalisations are of the form, Most X's are Y's Thus we say, Most comets go round the sun from East to West, Most men are selfish, Most Europeans are enterprising, Most cases of plague are fatal, and so on Some of these Approximate Generalisations are empirical, whereas some are derivative, or at least may turn out to be derivative. Thus, Most Europeans are

enterprising, is a partially derivative generalisation, because some reason may be assigned for this, but Most cases of plague are fatal, is an empirical generalisation still. It is the business of science to supply the reasons for such approximate generalisations and find out how an exception occurs This we can do by trying to convert an approximate generalisation into a mathematically exact statement Thus, we say, Most cases of plague are fatal If it be 80 p c. in Bombay, but 60 p c in a city like Ahmedabad or Surat, then we are in a position to connect the more or less per centage of the fatality with the changing conditions in these cities. Supposing it were establiaed by statistics that the more a city is overpopulated, the greater is the number of fatal cases, then by the Method of Concomitant Variations, we are in a position to find out the cause of the fatality. Statistics are thus useful in arriving at inductions, and approximate generalisations become serviceable when they can be converted into proportional statements of facts

2 LIMITS TO THE APPLICATION OF SECONDARY LAWS. No secondary Law, be it Empirical or Derivative, can be extended beyond the narrow limits of time, place and circumstance in which it is seen to hold good We can only rely upon it in "Adjacent Cases". i. e, cases in which the circumstances are similar There is this difference between an Empirical and a Derivative Law. We know not any of the conditions of an Empirical Law, hence we are entirely ignorant about the matter of the extent of its prevalence. But a Derivative Law depends on certain other laws, i e, it is deducible from other laws, and hence the extent of its application can be deduced from the extent of the application of the higher laws.

Of an Empirical Law, Carveth Read says: it "being one whose conditions we do not know, the extent of its

prevalence is still less ascertainable Where it has not been actually observed to be true, we cannot trust it unless the circumstances, on the whole, resemble so closely those amongst which it his been observed, that the unknown causes, whatever they may be, are likely to prevail there And, even then, we cannot have much confidence in it, for there may be unknown circumstances which entirely frustrate the effect"

" .. ..New stars shine in the sky and go out: species of plants and animals become extinct, diseases die out and fresh ones afflict mankind: all these things doubtless have their causes, but if we do not know what they are, we have no measure of the effects and cannot tell when or where they will happen."*

The Derivative Laws will apply to cases where the same collocation of agents on whose primary laws they depend exists Thus, the elliptical motions of planets are secondary laws, and are derivable from certain primary laws—the solar attraction (due to gravity) and the centrifugal force If any of these two forces is counteracted, the laws of planetary motion would change Hence we cannot extend them to all future

The rise of water in pumps was formerly shown to depend on an empirical law that no pumps could draw water beyond about 38 feet The law was established empirically by experiment in different countries. But so long as it was not derived from laws of pressure, it was applicable only in the countries where the experiment was tried Now, however, the law has become a derivative law, for we can deduce it from the law of the pressure of the atmosphere Hence, the limits of its application are

* (Logic, Deductive and Inductive, p 271-2)

now made definite, and we are not as much in the dark as we were when the law was empirical. Simply because the law depends on the law of atmospheric pressure, we are in a position to say that the height to which water may be pumped on high mountains would be less then 33 feet, and that it would not be the same in all climates, and for all liquids, for surely the pressure would differ in the case of mercury, alcohol, and so on In this way the limits of the application of a secondary law are known at once by ratiocination when it is a derivative law When, however, it is a purely empirical law, the limits are not definitely known, and if at all they are known, they are so known after trying many tedious experiments.

In the Medical Science the use of drugs is yet empirical. Owing to this fact we cannot infer that kindred medicines will have kindred effects. Thus bark and quinine are not interchangeable, though the one is the crude form and the other is the extract For the same reason it is not possible to apply the same treatment even to allied diseases

With reference to human character we have certain generalisations which hold good only under certain conditions, and it is impossible to extend them to the race generally. Thus Western nations as a rule are very polite to the female sex It would however be wrong to extend this rule in the East Oriental nations are as a rule more contented than Western and the rule of the Eastern people cannot be taken to be a rule of the human race generally. These rules are not merely empirical For we can deduce them from the civilisation and past traditions of the races concerned. The laws in that case become derivative. When they become derivative we can extend them to like cases Thus the Western people are polite towards the female

sex This quality they have acquired from their peculiar civilization and literature From this we may infer that whatever nations now follow their footsteps in education and civilization will very probably acquire this particular national trait As a matter of fact we notice that with the progress of Western civilization among Eastern races the trait in question is being acquired As a derivative law then we know the limits of the application of this national trait with tolerable precision.

QUESTIONS

(1) What is an Axiom ? Mention any axioms in Logic and Mathematics

(2) What are primary Laws ? Distinguish between an Axiom and a primary Law

(3) What is a Secondary Law ? How do you distinguish an Empirical from a Derivative Law? Give examples

(4) What are 'adjacent cases' ? What are the limits of Secondary Laws ? Is there any difference between the limits of Empirical, and of Derivative Laws ?

(5) Bain says, "While as an empirical law we cannot well extend the rising of the sun (or day and night as we now have it) beyond thousands of years at most, we may extend it, as a derivative law, to hundreds of thousands, if not to millions " Explain how this difference can be accounted for

(6) "It is an empirical law that about 250 persons in a year commit suicide in London" Supposing this is the average for the last hundred years in London, state (a) whether the law will hold good in the years 1920, (b) 1950 A D respectively in London Will it hold good of a city like Bombay ? If not, why not ? What is it that prevents you from extending the rule ?

(7) Can you make use of statistics in passing from an empirical to a derivative law ? Show how far statistics are useful in Approximate Generalisation

---

CHAPTER X

EXPLNATION

1 THE DIFFERENT KINDS OF EXPLANATION . SCIENTIFIC EXPLANATION.—Explanations may be of various kinds But we may note three chief kinds of them, (a) Formal, (b) Teleological, (c) Scientific or Mechanical Something is formally explained when a reason is supplied for its existence. Thus the mortality of man is formally explained when it is shown that it is deduced from his animality Teleological explanation is explanation by reference to an *end* or purpose for the existence of something This kind of explanation is the only explanation which enables us to understand the activities of life A man may be drowning and we may see another individual trying to save him We shall fail to understand the nature of this action unless we know the *end* the saviour has in view The saviour may be a police officer trying to arrest the drowning man, or he may be a philanthropic individual moved by the idea of relieving suffering and saving life as such, or he may be a creditor getting hold of the debtor in order that his money may not be lost, and so on Accordingly as the motive or end of action varies our judgment of the value we attach to it also varies Morality, Religion, History require explanation by reference to the end or final purpose of the action concerned. Such explanations are called teleological explanations From such explanations should be distinguished explanations which are mechanical Science takes note only of such explanations in the domain of material activities. Physics, Chemistry, Biology, etc—the Natural Sciences base their explanations on the laws of matter no note is taken of purpose or end. If an individual drowns, the mechanical explanation would be that his weight was more than the

quantity of water displaced and that would in a way be sufficient But the *meaning* of this action in life is not supplied when such an explanation is offered. The meanings may be different as the *ends* of the act are different The crowning may be with a view to shield a crime, or with a view to put an end to a life of physical sufferings, or with a view to protect oneself from moral degradation, and so on The meanings are in such cases different In the explanation of natural phenomena, the scientist takes no note of teleology but only of mechanical processes *Scientific explanation is causal explanation, a phenomenon is scientifically explained when it is inductively explained by reference to its cause.* The process of scientific explanation is identical with generalisation, assimilation, classification When we explain phenomena, we as it were make them "fraternize". their isolation disappears Thus, we give a scientific explanation of combustion when we assign oxidation as its cause and thereby fraternize it with the rusting of iron, the formation of red precipitate of mercury, etc the isolation of these phenomena disappears

2 MODES OF EXPLANATION.[1] —There are three modes of explanation

(1) Firstly, we have that mode of explanation in which we analyse a *joint effect* into the laws of the separate *causes* This is the ordinary Deductive process described by us

Thus, we explain the superiority of one nation to another when we analyse it into the innumerable separate

[1] The word Explanation ' used without any qualification would mean ' Scientific Explanation,' for Inductive Logic takes note only of this kind of explanation

causes which combine in bringing it about, e g, education trade, political institutions, military organisation, national character, &c, &c Each of these causes in itself requires scientific explanation, for it is complex.

We explain the running of a motor-car when we give the laws of motion, of friction, the property of petrol, of the rubber tyres, and the machinery of the motor

We explain the pumping of water when we analyse its causes into the pressure of air, the distribution of pressure in a liquid, and motion following the law of least resistance.

We explain so simple a thing as the speaking of anything—the use of language, when we trace all the psychological causes There is the use of perception, imagination, judgment as the chief psychological agencies, and a certain control over the nervo muscular apparatus over the face and jaws.

(2) Secondly, we have that mode of explanation in which we find out the *intermediate links* between an antecedent and a consequent

What seems at first sight immediate antecedence and sequence is very often a concatenation of causes and effects. Thus, in the example of speaking anything, we saw above that many causes operated together. But not only did they operate together, they were connected further in a chain. When we speak anything, e. g., "this horse is mine," utterance seems to follow immediately on the sight of the horse But as a matter of fact it is not so. Many rapid intermediate links are formed, and they are so rapid that they are unnoticed. Thus, there is first a sense-impresson, then a perception of a horse, which reminds me of my own horse, this memory brings about identification, and

the identification enables me to utter the sentence Again, the utterence itself has physiological and psychological chains of causes.

Take the case of the disharge of a gun. The ordinary explanation is that the trigger is drawn and as its effect we have the propulsion of a ball But the scientific explanation is found out only when we see that the two are only remotely connected For, first by concussion due to the drawing of the trigger, we get heat, the heat produces ignition of gunpowder, there is rapid combustion due to the special property of gunpowder, this causes evolution of gases which being confined in a small space have a high degree of expansive force, and finally, this force sets the ball in motion immediately

(3) Thirdly, we have that mode of explanation in which we *subsume* one law under another We show a given law to be a case of some one or more wider laws This is known as *subsumption* of one law under another

Thus the moon is attracted by the earth in the same way in which a stone on the earth is attracted by it Hence the two are subsumed under the wide law of gravity

The illustration of combustion as a mode of oxidation would be an example of subsumption Under the wider law of oxidation come the the law of the combustion of fire, the law of the rusting of iron, the law of the digestion of food in the animal system, the law of the formation of the red precipitate of mercury, &c, &c

Lightning is explained by its subsumption under the laws of Electricity.

The third mode of explanation represents the upward march of generalisation Inferior rules are explained by

their subsumption under higher and more general rules. As some of the highest rules under which inferior generalisations are subsumed we have the Law of Gravity, the Conservation of Energy, Magnetism, Electricity, The Law of Relativity in Psychology, the Laws of Thought in Logic, and so on

It is this mode of explanation which is closely connected with all philosophic aims The early Greek philosophers took a peculiar speculative delight in imagining one substance as the material cause of everything. Thus, Thales said that everything originated from Water, Anaximenes, that everything originated from Air, Anaximander, from an Indeterminate Substance, and so on. Even among modern philosophers, we find that the attempt to unify all experience under one principle is the goal of metaphysics It is a craving of this kind which is noticeable in the Oriental explanation that at bottom there is only one Reality, namely, the *Brahman*, and that the visible differences are due to modifications of the same in connection with the principle of Illusion "The intellect, oppressed with the variety and multiplicity of facts," says Bain, "is joyfully relieved by the simplification and the unity of a great principle"

3. Limits of explanation —Explanation being classification or generalisation, the limits of generalisation or induction are the limits of explanation Wherever a community of facts does not exist, explanation stops From the scientific point of view (though not from the philosophic point) we have the following limits to explanation.

(1) Firstly, fundamental states of consciousness are ultimate and cannot be explained There is no resemblance between sound, touch, smell, colour, heat, pleasure and

pain We cannot resolve a feeling of sound into a feeling of touch or sight or any other simple feeling So distinct are they from one another, that explanation is not possible

(2) Secondly, certain ultimate principles cannot be explained. Gravity and Molecular Adhesion are ultimate principles It is not possible to bring them under any other law Gravity is an attractive force, adhesion or cohesion is an attractive force Yet the modes in which the two operate are so very distinct that it is not possible to bring either of the two under a higher law With similarity only in the point of attraction, there is diversity in all matters Cohesion is separate for each substance, while gravity follows the law of the inverse square of the distance In the matter of its action in space, cohesion decreases according to distance much more rapidly than this, and so on It is not thus possible to assimilate the one with the other. So, of the other ultimate laws of Nature

(3) Thirdly, we have a limit to explanation whenever we come down to individual facts The character of an individual is so very infinite that it is never possible to define it Proper Names are for this reason regarded as non—connotative. One individual differs from another by an infinite number of attributes, hence explanation stops with individuals. Why a particular bench in the Victoria Garden is just where it is, with just the dust it has on it, being only just away from a particular tree by a certain distance, and so on are things which cannot be explained. The causes of the infinite co—existences and sequences noticeable in the existence of an individul or a particular fact are infinite, and hence no explanation of the same may be given.

Note DEFINITION AND MODES OF EXPLANATION —Mellone defines Explanation as "essentially a bringing of the particular, or less general, under the universal or more general" (p 326, Introductory Text-Book of Logic) This definition aims at a two-fold classification of Explanations, the Explanation of a fact by a law as being that of a particular by a general, and the Explanation of a law by a wider law is being that of a less general by a more general

The definition given in the Chapter is simpler than that in the above paragraph Wherever there is generalisation or assimilation, there is Explanation When a fact is brought under a law we assimilate it with other facts when a less general law is brought under a more general law, we assimilate it with the latter Explanation is thus nothing more than Assimilation

When we speak of the different *modes* of Explanation we do not speak of different varieties or kinds of the same but only of different illustrations or better different *aspects* of it The *kind* of explanation is the same it is *causal* or *scientific*

Usually *three* such aspects are noted, namely the resolution of a joint effect into the separate causes, the giving of intermediate links between an antecedent and a consequent, and the subsumption of the less general under the more general law All these aspects have direct scientific utility Simplification may be attempted by mentioning two modes of Explanation, as that of a fact by a law, and that of a less general law by a more general law. But here it should be noted that the more interesting and ultimately scientific form of Explanation of a fact by a law is bound to lead us to the ultimate resolution of a fact (effect) into its many causes, or to the tracing of intermediate links between the fact and some remote antecedent

QUESTIONS

(1) What is the popular meaning of Explanation? How is it connected with the scientific idea of the same?

(2) Explain the different modes of Explanation

(3) What are the limits of Explanation ?

(4) Show that Explanation is assimilation

(5) How do you explain the following ? State the exact mode of explanation

(a) One man abusing another, and the latter beating the former

(b) Success at an examination,

(c) The taking of poison causing death,

(d) Success in a cricket—match,

(e) The elliptical motion of the planets in the Solar System,

(f) The motion of a Railway-train,

and (g) Your own education

CHAPTER XI

PROBABLE REASONING

1 PROBABLE REASONING —By this expression is meant reasoning from premisses which are probable If one premiss is certain and the other is probable, a probable conclusion may follow, e g, All great poets are men of genius, Narmadâshanker is probably a great poet, hence he is probably a man of genius We cannot conclude that N. is certainly a man of genius Again, syllogisms in which the major premiss begins with 'Most' and the minor premiss is a singular proposition, are of this type, e g, Most children who are habituated to experience wonder turn out scientists in later life, X is a child habituated to experience wonder, and therefore, X will probably turn out a scientist in later life The major premiss is equivalent to the proposition "A child who is habituated to experience wonder will *probably* turn out a sciensist in later life" If a particular thing is true in most cases, it is probably true in any particular case Hence a modal conclusion is possible in cases of this type

When events occur by chance we cannot infer an uniformity In empirical laws we cannot infer an uniformity The inductive methods are in such cases not applicable, at any rate they do not give definite results

But by a rational calculation some kind of probable reasoning is possible even then Chance is usually regarded as in antithesis to law But this is not so For whenever anything happens it is due to *some cause*, and not to chance What is called chance is "a coincidence from which we have no ground to infer uniformity." But if we know the details of the coincidence, we can calculate some kind of probability for our guidance

2 EXPLANATION OF THE WORDS "PROBABLE," "PROBABLY" "PROBABILITY," "ODDS FOR," "ODDS AGAINT":—"Probable" means "more likely than not" when it is used as a predicate, e. g, "my coming to you this evening is probable" "Probable" is used as qualifying a substantive, and then it may mean either (1) more likely than not, or (2) not certain, e g, (1)" probable events," "probable success," etc, (2) "probable premisses," "probable arguments." "Probably" always means "more likely than not," e g, "he will probably die" "Probability" again has a two-fold meaning, (1) more likely than not, (2) chance i e., any fraction between certainty or unity, and impossibility or zero: e g. (1) "His death is now a probability," (2) 'The probability in this case is 3/8,' In this case the probability or chance or expectation is 3/8.' i. e., the odds for the event happening are 3: 5, whereas the odds against are 5: 3.

3. RULES FOR THE CALCULATION OF PROBABILITIES — (1) Probability of the occurrence of *either* of two events that do not concur If two events or causes are independent of each other the probability of *one or the other* occurring is the sum of the separate probabilities of each. If one man in ten is over six feet and one man in ten is under five, then in a large number, e. g., 1000, there will be 100 men over six feet, and 100 men under five feet i. e., 200 will represent

the number of the *one* or the *other* kind. This number we get by adding up the separate fractions, thus $\frac{1}{10}+\frac{1}{10}=\frac{2}{10}$, i e., $\frac{200}{1000}$

(2) Probability of two independent events occurring together If two events or causes are independent then the probability of *both of them occurring together* is calculated by multiplying the fractions of the probabilities of each event occuring. If I go to the Victoria Garden once in a week and my friend goes there twice a week, the probability of both of us together going to the place will be $\frac{1}{7}\times\frac{2}{7}=\frac{2}{49}$.

This is quite evident. For, since I visit the place once in a week, I will visit it for 7 days out of 49. Since we wish to find out the number of days when my friend will be at the Garden when I am there, I must leave out of consideration 42 out of 49 days when I shall be absent Of the seven days when I shall be at the Garden my friend will be there for *two* days, since he visits twice a week quite *independently* i e., he does not mind whether I am to go or not, his going to the Garden is quite independent There is neither repugnance nor connection between my friend's going and my going. Hence, he will be at the garden twice out of the seven days when I am there The probabilitly of both of us being at the Garden is thus 2 out of 49, or $\frac{1}{7}\times\frac{2}{7}$ or the multiplication of the probability of each event occurring

(3) Probability of two dependent events occurring together:—If one event or cause is dependent on the other, the 2nd rule will apply when we want to find out the joint probability Thus if my going to the Victoria Garden *depends* on my friend's going, a case of the kind contemplated occurs.

If I go there once out of seven times when may friend comes to me, and my friend comes to me twice out of seven days, I shall go to the garden twice out of forty-nine days. For my friend will come to me 14 out of 49 days, and out of these 14 days I shall go to the Garden only twice This is the rule which is useful in deciding the result of what is called *chain-reasoning*. A tells what B told him, B tells what C heard from D and tells him, D tells what he read in the newspapers, the newspapers copy down what was written by a particular correspondent and so on Here if any one of the links is weak the whole argument goes to the ground. What A has heard at the 5th or 6th remove is decidedly more untrustworthy than what either B, C, D, E heard, the combined effect of this kind of chain is to invalidate the whole evidence Contrasted with this are cases of corroborative, circumstantial, and analogical arguments, *the various parts of which strengthen each other*. Thus X says, 'he saw B murder C,' and Y says the same thing The probability of the truth being told is here greater than in the case in which one of these two persons gives the report Again, Y might be an utter liar and yet X's statements will remain as credible as they are. Because one witness is a liar the whole evidence does not become useless In a chain argument the case in different X may be a truthful person, but if he says what Y told him, the mere fact that Y is a liar will render X's statements entirely useless The rule for calculating probabilities in cumulative evidence, or corroborative testimony, or analogical arguments must therefore be a different one and Rule 4 is then to be a used.

Rule (4). Probability in cumulative, corroborative, or analogical arguments —The probability of two or more independent events or causes coinciding with one another

or establishing one and the same point will be found by multiplying the fractions representing the improbability of each event which establishes the main point and subtracting the result from unity Thus if A tells 5 correct statements out of 9, and B tells only 2 correct statements out of 9, and both of these events coincide i e, both A and B state one and the same thing (e g, that X was seen by him, being murdered by Y), the probability of the truth being told by them is $1-\frac{4}{9}\times\frac{7}{9}$(multiplication of the fmprobabilities of the truth being told)$=\frac{53}{81}$ This is quite evident For out of 81 statements in all, *A makes* $81\times\frac{5}{9}$ or 45 *correct statements* Hence we are sure of 45 out of 81 statements 36 statements remain to be examined B gives 2 correct statements out of 9, and hence, out of these, 36 statements which remain to be examined, *B will make* $36\times\frac{2}{9}=8$ *correct statements* Thus $45+8$ or 53 correct statements will be made in all, if we examine 81 statements made by A and B This is the same as saying that the improbability of A's making a correct statement is $\frac{4}{9}$, which multiplied by the improbability of B's making a correct statement($\frac{7}{9}$), gives the fraction $\frac{28}{81}$ The probability of more statements being correct here increases, and since unity represents certainty, $1-\frac{28}{81}$, or $\frac{53}{81}$ will be the fraction which represents the probability of the statements made by A and B being correct.

Questions and Answers

Solve the following cases of probabilities—

(a) The probability of A's being enlisted as a soldier is 1/5, and that of B's being enlisted is $\frac{2}{3}$ Determine the probability, (1) of either of them being enlisted, (2) of both of them being enlisted.

(1) $\frac{1}{5}+\frac{2}{5}$ or $\frac{3}{5}$, is the probability of either of the two being enlisted.

(2) $\frac{1}{5}\times\frac{2}{5}$ or $\frac{2}{25}$ is the probability of *both* being enlisted.

(b) The probability of A's being enlisted as a soldier is 1/5, whereas the probability of a soldier dying while on an expedition is $\frac{2}{3}$ Determine the improbability of A's dying on an expedition.

This is a case of dependent probability $\frac{1}{5}\times\frac{2}{3}$ or $\frac{2}{15}$ is the probability of A's dying in an expedition, i.e., $\frac{13}{15}$ is the improbability.

(c) Two persons A and B are trained in archery and try to hit a point in a target. The chances of A making correct hits are 5 out of 8, whereas B fails in 3 out of 10 cases. Find out the probability of a correct hit being made at once by A and B provided they two try together?

When the correct hit is to be made *at once* the probability is greatly weakened and this is calculated by multiplying the fractions of the separate probabilies, i e., $\frac{5}{8}\times\frac{7}{10}$ or $\frac{7}{16}$ $(\frac{35}{80})$. For when both try 80 hits at once, A is sure to make correct hits for 50 times, and out of these 50, B makes 35 correct hits. Hence 35 out of 80 or $\frac{7}{16}$ is the fraction required.

(d) I open my cup board and without reading the name of the book try to take out Bacon's "Advancement of Learning." If a certain other book is so like the one I want that the chances of mistake are 5 out of 7, and the chances of that other book being just

near "The Advancement" are 7 out of 15, determine the chances of mistake

$\frac{5}{7} \times \frac{7}{15} = \frac{1}{3}$ is the probability of mistake.

(e) When there is plague in a city, two out of 100 men are attacked because of nevousness, the improbability of a man's being attacked by contagion is $\frac{1}{100}$, and the probability of a man dying when once attacked is $\frac{3}{4}$ Determine (1) either of these probabilities, (2) a man being attacked through nervousness and dying, (3) a man's not being nervous, and coming into contagion and yet not being attacked, and (4) a man's at once getting nervous, being attacked after coming into contagion, and dying

(1) $\frac{2}{100} + \frac{99}{100} + \frac{75}{100}\left(\frac{3}{4}\right) = \frac{176}{100}$, i e, it is certain one or the other of the three things will happen *if the statistics be as supposed*

(2) $\frac{2}{100} \times \frac{3}{4} = \frac{3}{200}$, probability of a man getting nervous, being attacked and dying

(3) $\frac{98}{100} \times \frac{1}{100} = \frac{49}{5000}$ [$\frac{1}{100}$ is the fraction to be taken into consideration, since 99 out of 100 are attacked through contagion The fraction 98/100 is clear]

(4) $\frac{2}{100} \times \frac{99}{100} \times \frac{3}{4} = \frac{297}{20000}$

EXERCISES

(A) Calculate the following probabilities —

(*a*) A shop-keeper in Baroda has a gramophone in his shop, which he uses for the purpose of attracting customers He has 14 records in all, one of these reproducing a famous song by Gauhar Jan He uses the machine after 6 p m every day, utilizing all the records daily, but one once only Suppose that one out of four machines of the kind kept

by the shop-keeper does not turn out to be a good one that only four out of fifteen records are newly bought, and that a customer A is in the shop on a particular day for a length of time during which only one song is fully heard Determine the probability of A's hearing Gauhar Jan's song and at the same time the record being new and the machine good

(*b*) Three persons A B, and C give independent descriptions of a comet which was visible from the top of Mt. Pavagadh C however states what D told him and D had repeated to C what E had seen and told him A and B had seen the comet themselves. Supposing that out of 4 statements, A makes 1 correct statement, B 2 out of 3 C 1 out of 2 D 1 out of 2, and E 1 out of 2—what is the joint probability of the reports of A B, and C being correct?

(*c*) Supposing in a city like Ahmedabad 1 out of 7 hackney carriages has an underfed horse only 1 out of 5 is rubber-tyred 1 out of 7 has a rickety frame and 7 out of 24 drivers in the case of private carriages are used to rash-driving and come into clash with other carriages Determine (1) the probability of my having had to put up either with a carriage with an underfed horse or without a rubber-tyre, or with a carriage having a rickety frame (2) my being in a carriage without rubber-tyre having an underfed horse a rickety frame, and suffering an accident by coming into clash with a private carriage, (3) the improbability of my getting an underfed horse and a rickety frame

(*d*) A and B are supposed equally likely to produce an effect X If A exists in nature twice as much as B exists but in 50 out of 100 cases A is counteracted by M in producing the effect while B is counteracted by N in 10 out of 100 cases determine the relative probabilities of A's producing X and B's producing X.

(*e*) 'My informant A heard his story from B who would certainly tell it as originally told to him B heard it from C, who would probably tell it accurately C from D who would also probably tell it accurately D from E, who I

are said to argue analogically when we argue as under:

As health : the body : : virtue : : the soul.

Here there is an equality of ratios, virtue bearing the same relation to the soul, as health does to the body. According to the modern sense, however, we do not want to establish equality of relations or ratios, but to carry on an inference on the ground of resemblance Thus, if A and B resemble in certain respects x and y. we infer that they will resemble also in another respect z If the Earth and Mars resemble in the possession of an atmosphere we infer analogically that they resemble in being inhabited.

There is, however, *essential difference* between the Aristotelian and Modern sense of Analogy, for similarity of relations must imply some similarity of nature or qualities, and the extensions of the term Analogy from the former to the latter sense is quite natural

3 ANALOGY DISTINGUISHED FROM DEDUCTION, INDUCTION, AND SIMPLE ENUMERATION:—Like Deduction and Induction, Analogy starts with the *assumption* that things which are *alike in some respects are also alike in others* But whereas in Deduction and Induction we can assign a reason connecting the cases in hand with a general statement with reference to the essential points of resemblance, we cannot do so in Analogy. Thus, if it were a deductive argument we shall have to infer thus, "All planets having an atmosphere, temperature, weather, clouds, &c are peopled," "X is such a planet," therefore, 'it is peopled" But it is not possible to lay down such a major premiss as is proposed in this syllogism, for we do not know definitely all the essential points on which life depends. If such a categorical statement can be made, then our inference from it to a particular case will be

Deductive In an anological inference, however, we are unable to appeal or at least do not appeal to a definite general law assigning the essential points of resemblance on which the argument depends

In Induction also we can assign the essential conditions, namely, the exact points on which the inference depends In Analogy we cannot do this In a valid Induction the conclusion rests upon the fact that the antecedents from which you infer the consequents are *causes*. whereas this kind of definite knowledge is not present in analogical inference

Analogy is an imperfect kind of induction Hence it is to be distinguished from Simple Enumeration In an Induction per Simple Enumeration we simply count the number of like cases, and hence infer that the next case will be similar Thus, if a foreigner on coming to India sees only Bombay, Calcutta, and Madras, has no other knowledge from reading or otherwise, and from this infers that all Indian cities are rich, his generalisation or induction is based on Simple Enumeration. In Analogy, however, we do *not* count *the number of like cases*, but *weigh the like points or resemblances*, and from thence generalise. We do not count but we weigh the resemblances, we do not look to like cases but to like points Thus if I were to infer *simply* that just as Bombay is overpopulated, and unhealthy, so too is any other overpopulated city unhealthy, my inference would be analogical There is resemblance in one point, therefore we infer that there is resemblance also in another. If I have a knowledge that "all overpopulated cities are unhealthy," then my inference would be deductive. If not, it is analogical It rests on points of *resemblance simply* and purely. For this reason, it differs from Induction per

Simple Enumeration which rests on the *number* of like *cases*, and not on like *points* or on the *value* of *like points*.

4 THE CONDITIONS OF GOODNESS IN AN ANALOGY.—According to Mill, we can test the value of an analogical inference by *counting* the *number of independent points* of *similarity*, and contrasting them with the *number* of *independent points of difference*, and with the *total number of known and unknown points* in the nature of the two phenomena If the points of similarity exceed, the analogy is well-grounded, otherwise it is not so. This is neither a *feasible*, nor a *valid* test of the value of analogy. It is not *feasible* for the evident reason that the unknown points cannot be determined. How can one *know* the number of *unknown* points in the two phenomena compared? It is not a *valid* test, for the value of an anological argument does not depend on an *arithmetical* calculation of the points of similarity and difference, but on the *value*, the *importance*, or the *weight* of the same. Similarities and differences should be weighed, and not counted Merely because two things resemble in *many* points, it cannot be inferred that they will resemble in any other point too Two cities may have the same population, may belong to the same country, may have the same kinds of buildings may have the same type of civilization, and may be under the same sovereignty, and yet one cannot infer that if the one is industrially thriving, the other too will be thriving. The reason is that not one of the points of similarity is *important*, i. e, is *probably causally connected with the point inferred*, industrial prosperity.

The true test of the goodness of an analogy is therefore the greater *importance* of the similarity as contrasted

* (System of Logic, Bk III ch XX. 2)

with the difference between the phenomena or facts compared The Earth and Mars resemble in having an atmosphere, a surface distributed in land and water, a temperature which is habitable, and motion round the sun in an elliptical orbit. The points of resemblance are many, but only two are important, namely, having an atmosphere and a habitable temperature. These points are *probably* causally connected with human life and hence the analogy cannot be rejected But still the probability is not very great since nothing is known of the presence of oxygen, the exact temperature and such other points as might be deemed more probably causally connected with human life The Earth and Moon have many points of similarity, but with an important difference; there is no atmosphere in the moon The absence of the atmosphere is an important difference. hence we may conclude that there is no human life in the Moon.

5. THE LIMITS OF ANALOGY.—The reason why it is stated above that the points of similarity are to be deemed *important* when they are *probably causally connected* with the point inferred is, that if the connection is more than that the argument ceases to be an analogical one Then, for example one may simply proceed thus All planets which possess the properties x, y, z are inhabited, Mars has them, and is therefore inhabited i. e, that the argument would be *deduction* based on a major premise which is an *induction* stating a *causal relation* between x, y, z and life The difficulty here and elsewhere would be in determining these x, y, z, i e, just the conditions on which life or the inferred property depends As these conditions are not *definitely* known, we necessarily take hold of the conditions *probably* causally connected Thus we are within the limits of

analogy *only so long as* the points of similarity and dissimilarity are *probably causally* connected or disconnected respectively with the property inferred.

ILLUSTRATIONS

(1) X and Y are both lawyers They resemble in having the LL. B. degree, in being educated in the same College, and in being very intelligent X has further the character of making people quarrel. To infer that Y who has many points of similarity with X has also this other characteristic is to infer analogically but quite illegitimately. For mere knowledge has no connection with evil dispositions In X's case the evil habit is very probably connected with his evil *desire* In Y this desire is not sought for and is not known to exist The inference is therefore illegitimate

(2) The universe resembles a well-contrived machine. It must therefore resemble the latter in the fact that it has a Maker The resemblance is in acting up to some purpose, in having inter-connections between different parts of the whole, like those between means and end, and in appearing well-ordered generally As the machine is made by some maker, so the universe must have been made by some Maker The analogy breaks down for there is an important difference the machine is *externally* determined, the universe is *internally* determined. That which has brought order in the Universe is *scientifically conceived* as being *of the universe*, but the intelligence which contrived the machine is *external* to it If it be an analogical argument to prove the existence of God, it has not great weight For if the universe is scientifically conceived as being self determined, probably there is no necessity of having a Maker external to it

(3) As Coffey says:* "*A pari*," "*a fortiori*," and "*a conrario*" arguments, are all arguments from analogy· "The planet Mars bears a close resemblance to our Earth, therefore, *a pari*, it is porobably inhabited." "Woik in the mines is hard on the health of male adults, therefore, a *a fortiori*' it is injurious to women and children" "The abuse of alcohol is a cause of national decay, therefore, *a contrario*, the suppression of that abuse will make for national prosperity"

These arguments should all be tested by the conditions for determining the goodness of an Analogy

---

QUESTIONS

(1) What is Analogy? Distinguish between Aristotelian Analogy and Modern Anafogy

(2) Show that an argument based on Analogy is like an argument based on Simple Enumeration an imp erfect induction

(3) How will you decide the value of an analogical argument?

(4) Distinguish between arguments based on

(*a*) Analogy and Deduction,

(*b*) Analogy and Induction,

(c) Analogy and Simple Enumeration,

(5) Explain "The argument by Enumeration gives way to an argument from Analogy so soon as attention is turned from an enumeration of observed instances to an analysis of their character" Boyce Gibson

(6) Give two illustrations of an analogical inference in practical affairs in such a way that in the one there is a high degree of probability of the infernce being correct, in the other nil

(7) Explain the following fully —

If having tried with a stick, a stone, a shoe, &c, we find that they all break an ordinary window glass, and thence infer that a bullet will do so, we do not reason by analogy, but

* The Science of Logic, vol II, p 158

make instinctively a deductive application of an induction But if knowing nothing about dogs except that street-dogs bark and at times bite, a child is unwilling to play with a domestic dog, he acts on Analogy but his inference is wrong

(b) What are the limits of an Analogical argument as distinguished from a Scientific Induction ?

CHAPTER XIII

FALLACIES INCIDENT TO INDUCTION

I CLASSIFICATION OF INDUCTIVE FALLACIES —The fallacies incident to Induction are mainly of a two-fold nature, for they might be due to errors either in the processes subsidiary to Induction or in the Inductions themselves Accordingly the following is a classification of Inductive Fallacies·—

I Fallacis due to errors in processes subsidiary to Induction:

(a) Fallacies of Misobervation, i e,

(i) of Not-Observation,

(ii) of Mal-Observation.

(b) Fallacies incidental to Classification, Nomenclature, Terminology.

(c) Fallacies incidental to Hypothesis

II Fallacies due to errors in inductions themselves, i e, in the generalisations:

(a) Fallacies due to Induction per Simple Enumeration.

(b) Fallacies due to imperfect fulfilment of the conditions of the Inductive Methods.

(c) Fallacies due to Erroneous Analogies

If no detailed account of I (*b*) and (*c*), i. e., the Fallacies incidental to Classification and Hypothesis is to be taken, we have a very simple classification as under:—

Fallacies due to *Erroneous Observation*,
Fallacies due to *Erroneous Generalisation*,
and Fallacies due to *Erroneous Analogies*.

II (a) and (b) are included in Fallacies due to Erroneous Generalisation. Fallacies due to Erroneous Analogies are kept separate from Fallacies due to Erroneous Generalisation, because Analogies are imperfect inductions and the error consists in mistaking them for perfect or scientific inductions, whereas in the Fallacies due to Erroneous Generalisation the inductions are deemed to be scientifically valid but as a matter of fact turn out to be erroneous

2 I (a) FALLACIES OF MISOBSERVATION —The fallacies due to erroneous obsevation are either negative or positive One might omit to observe certain facts which exist, or observe wrongly fact which do not exist as such The two errors are errors of omission, and of commission Accordingly, we have Fallacies of Non—observation, and Fallacies of Mal--observation, the former being negative, the latter positive

1 FALLACIES OF NON-OBSERVATION.—These are subdivisible into two kinds of fallacies For non-observation may consist either in overlooking *instances*, or in overlooking the *circumstances* connected with instances Thus, if we were to say that a particular general was always successful on the field, overlooking instances of defeat, we would commit the fallacy due to Non—observation of Instances, whereas, if the successes of the general were due to the fact that he had assistance from powerful allies which we do not take into consideration and attribute credit always to him, the fallacy would be due to Non—observation of circumstances Mill gives a nice illustration of the distinction: "If we were to conclude that a fortune- teller was

a true prophet, from not adverting to the cases in which his predictions had been falsified by the event, this would be non-observation of instances; but if we overlooked or remained ignorant of the fact that in cases where the predictions had been fulfilled he had been in collusion with some one who had given him the information on which they were grounded, this would be non—observation of circumstances."* Of course, if the contradictory instances or circumstances had beed observed, and yet we were to praise the fortune-teller, the error would be in our generalisation and not in our observation

Non-observation of instances is a common error, and is due to various causes The human intellect is prone to take note of affirmative rather than negative instances. Many familiar examples of this tendency will occur to us. Thus the speculator's mind takes note of the instances in which his friends profit by speculation. In the selection of a profession, one observes the limited number of cases of the most successful men in a profession Dreams are supposed to be predictions of coming events, and by coincidence some events do happen as dreamt and an induction is accordingly established. It is erroneous, because there is non-observation of the innumerable instanaes in which the sequences do not happen In addition to the frailty of the human mind, there are other causes from which neglect of observation originates There are biases and prejudices in scientific as well as other matters The mind very seldom judges dispassionately. Thus, even in philosophic matters, it depends much on your moods and sentiments whether you become a Rationalist or an Empiricist, and so on. Beliefs in ghosts, spirits, and certain

* System of Logic, V iv 2

types of idolatry have their sole origin in mental bias, for no instances ever support them Our social prejudices owe their strength to this kind of fallacy. We are unfavourably impressed with some foreign customs, then we never take the trouble of observing good customs Evidently a generalisation from such data is bound to be erroneous

A very good illustration of Non-observation due to preconceived theories (bias) is the following —

"The opponents of Copernicus argued that the earth did not move, because if it did, a stone let fall from the top of a high tower would not reach the ground at the root of the tower, but at a little distance from it in a contrary direction to the earth's course in the same manner (said they) as, if a ball is let fall from a mast head while the ship is in full sail, it does not fall exactly at the foot of the mast, but nearer to the stern of the vessel The Copernicans would have silenced these objectors at once if they had *tried* dropping a ball from the masthead, since they would have found that it does fall exactly at the foot as the theory requires but no, they admitted the spurious fact and struggled vainly to make out a difference between the two cases"*

The second division of the Fallacy of Non-Observation is the Fallacy which is due to the fact that we do not observe the circumstances attending certain phenomena The instances are observed but their details are not The defect does not consist in omitting to take a survey of the wide number of instances, but of the exact character of the instances Thus if we attribute magical performances to the magician's wand, the error we commit is that of not

* (Mill, System of Logic V iv 3)

observing the circumstances connected with the same. The music and the skill of the magician attract us to a different driection, and the mehanical contrivances owing to which the charms are worked pass away unnoticed. The complexity of social and economic subjects being great this kind of fallacy very easily besets them Thus a social reformer may claim to support his cause and assert that only reformed notions and their prevalence have brought about a change in social institutions, e.g , dinners, marriage, aud so on. But it may be that eduction and changed economic condition also, may be accompanying causes. With a new system of education, old customs are bound to change, with increase of expenses, and an expensive modern life generally, changes are bound to happen in old institutions. The tussel between the new and the old will almost disappear if both schools take a note of all the circumstances of the case. There is a nice illustration of non-observation of circumstances, which attracted considerable attention of scientific men. It is the well known example of what was known as Kenelm Digby's Sumpathetic Powder —

"The sympathetic powder was that which cured by anointng the weapon with its salve instead of the wound I have long been convinced that it was efficacious The directions were to keep the wound clean and cool, and to take care of diet, rubbing the salve on the knife or sword. If we remember the dreadful notions upon drugs which prevailed, both as to quantity and quality, we shall readily see that any way of *not* dressing the wound would have been useful."*

The circumstance that nature itself cures the wound was not noticed, and the efficacy for a long time attributed to the sympathetic powder.

* De Morgan, *Budget of Paradoxes*, p 66

Many of the quack doctors in this country know well how to make use of devices by means of which the cure may be attributed to their medicines which are neutral, when as a fact it is due to the attending details in the matter of diet and habits the patients have to observe

The celebrated phlogistic theory owed its origin simply to a non-observation of details, For it was a theory to account for the fact that in combustion something disappeared from substances The ascent of flame, and the diminution in weight and bulk of the ashes which remain after combustion naturally suggested the hypothesis of Phlogiston The erroneous hypothesis could however have never come into existence had the residuary products in combustion, namely gaseous products, been taken into consideration When this was noticed it was found that substances do not lose but gain weight by undergoing combustion (Refer to chap. VI. *pp. 101–2* of this book)

ii. FALLACIES OF MAL-OBSERVATION:—Mal-observation is due to wrong interpretations of what we see, hear, feel, and receive impressions of. It consists in erroneous interpretations of sense-impressions Our perceptions of things are mainly interpretations from signs, for we never see the whole aspect of things but generally interpret what a thing is from the partial aspect which presents itself to us Thus, in the dark, we see a rope, and fear it as being a serpent. The fear is due to a wrong interpretation. The sense-impression is there, but it is wrongly interpreted, for owing to darkness, one is not able to see the rope in all its aspects, only the thickness, the curve, and blackness are seen, and a wrong interpretation made. If the rigidity and the remaining aspects are also observed the perception would be a correct one as a rope, and not as a serpent

Just so the rustic frightened by an unaccountable sound in the dark at midnight fears a ghost. The sound is there, but it is not due to the agency of a spirit. It may be due to wind, it may be due to some animal setting something in motion and all this without being noticed. This is what makes the rustic infer wrongly. What are known as illusions or hallucinations are psychologically explicable in this way. They are due to Mal-observation; a part of something being observed, and from that wrong perception being interpreted.

A very simple example of an universal error due to Mal-observation was the resistance made to the Copernican theory on the ground of common sense. When people *saw* the sun rise and set, how could they believe otherwise? "We now know" says Mill, "that they saw no such thing; what they really saw was a set of appearances equally reconcileable with the theory they held and with a different one"

Railway-travelling supplies another instance of Mal-observation It is the train which begins to move, and yet the trees and other things near it seem to move in the opposite direction. What is seen is motion. But what is inferred is wrongly inferred No sooner do we compare the relative position of the apparently moving objects with some stationary background than we realise that it is we who move and not those objects.

If we cross the two fingers of our hand and roll a pea in the fork between them we shall be fully persuaded that there are *two* peas especially if our eyes are closed, i. e, if the feeling of touch is not corrected by the feeling of sight. The touches on the usually separate portions of the fingers are interpreted as due to two separate objects. Hence we misinterpret our experience.

I (b) and (c) Fallacies incidental to Classification, Nomenclature, Terminology, and Hypothesis are sufficiently illustrated in chap VI of this book.

3. II a. FALLACIES DUE TO INDUCTION PER SIMPLE ENUMERATION:—In its broadest form, the fallacy due to induction per simple enumeration is the basis of good many illicit generalisations. All emprical generalisations are true only within known limits, and can be applied only to adjacent cases and that too not with surety. Thus averages of a sufficiently accurate character can be struck out in the matter of death-rate, crimes, lost letters in a year, &c, &c. These averages, however, will hold true of any future year, or any other city or country, only if the same causes which were at work in the cases examined will combine in the future, or at the different places Losing sight of this, if the averages are extended from one time to another, or one place to another; the fallacy we commit is an undue extension of an emprical generalization. It is due to an unreflecting application of Induction per simple Enumeration, for averages which are true of certain limis, i.e, certain instances, are extended to all cases.

Another fallacy of this type is the one due to undue respect for authority. Now what a great thinker says, may be true under particular circumstances but not always. It is no use quoting Plato and Aristotle to reform the modern moral code. In paying an undue respect to authority we commit an error due to enumerative induction. A special form of inductive error due to respect for authority is visible in practical affairs. A certain individual A or B is a well-known leader in social or political matters Hence he would do as a Director of some Mill or Bank, or any new Company. This is the way people seem to think, for men

are deceived and new business easily floated on the credit of such names. The error committed here is that of enumerative induction. A or B is an individual whose opinions are of weight in social or political matters, therefore they are true in *all* matters. This is the argument we seem to carry, it originates in Induction per Simple Enumeration. "We have to learn," says Dr. Fowler, "not only that men are to be trusted exclusively within the limits of their own experience, in their own profession, or pursuit but that even within those limits their authority is apt to become tyrannical and irrational unless it is constantly confronted with facts and subjected to the criticism of others."*

4 POST HOC, ERGO PROPTER HOC—may be regarded as a fallacy of this type. Merely because two events are joined in experience successively (or simultaneously), to assume that they are causally connected, i e, will always observe the conjunction, is an error due to enumerative induction. The inference in connection with Kenelm Digby's sympathetic powder may also be regarded as a case of this fallacy, for the anointing of the weapon accompanied the cure of the wound, but yet it was not causally connected with the same. The cure was conditional on processes of natural healing. If they were stopped, the result would not be forthcoming though the weapon be anointed.

5. II (b). FALLACIES DUE TO IMPERFECT FULFILMENT OF THE CONDITIONS OF THE INDUCTIVE METHODS:—
The following are the chief errors under this head.

(1) To lose sight of the mutuality of cause and effect where the two act and react on one another. Education is the cause of civilization and civilization of education. It

* (Inductive Logic, p 292)

is erroneous to regard only the one as the cause of the other. Riches beget industry, and industry riches Where the latter is the case, it would be inverting the relation of cause and effect to say that in the case in question riches were the cause of industry. Social and political phenomena are very complex to deal with, no elements completely disappear and the error in question is then very likely.

(ii) To mistake the effect for the cause and the cause for the effect: This error is common in historical speculations It would be illustrated only when inductions have to be based on observation unaided by experiments. This is the case with historical speculations, and speculations on certain physical phenomena Thus if the French Revolution be regarded as the cause of a certain change in social and political events in France, when it was as a matter of fact the result of the same, the error in question is exemplified. The new political constitution in Japan is the result of a change of political and social conditions due to contact with Western nations. It would therefore be erroneous to attribute the present condition of Japan to its limited monarchy. Very often it is not possible to decide which is the cause and which the effect, e. g., as in many meteorological problems In such cases it is better to suspend judgment rather than hazard a rash induction.

(iii). To mistake an antecedent as a cause when another is really so Inasmuch as the conditions also of the process of inference itself are concerned, they are violated in the inference from Kenelm Digby's sympathetic cure *Post hoc, ergo propter hoc.* Inferences from omens, augury, horoscope, and prophetic dreams are all beset with this fallacy. Merely because certain birds are seen by an

army just before a battle which turns out to be victorious, it does not follow that the omen was the cause of the victory. The conditions of the concept of cause are not satisfied in the case, for the sequence is not invariable, immediate, and unconditional.

(iv) The mistake that an event is due entirely to one cause when it is only partially so due: If we attribute improvement in our health as being due to medicine alone, when as a matter of fact change of air may have operated as a concurring cause, this is the error we commit. The prevalent notion is that the heart is the sole cause of the circulation of the blood, but this is not so. For "there have been cases of men and animals born without a heart: these acardiac monsters did not live: but they had grown and developed in the womb, and consequently their blood must have circulated"*

Illustration of this error are easy to find in erroneous historical and political generalisations It would thus be erroneous to attribute the causality of the whole of the progress in Akbar's reign to his personality, for he would not have succeeded had other remarkable personalities like Todar Mal and others not assisted him.

(v) To mistake a condition for a cause: This fallacy will be found sufficiently explained in the Chapter on Causation.

(vi) To mistake joint effects as cause and effect. Day precedes night and night day, yet both are co effects. The ebbing and the flowing tide are similarly co-effects and it would be absurd to say that the ebbing tide is the cause

* Lewes, Physiology of Common Life, vol i p 322 quoted by Fowler

of the flowing tide simply because there is invariable antecedence and sequence. The error of mistaking signs or sympotoms for causes is also of this nature In many cases of illness fever accompanies, yet it is simply sympathetic, being the co-effect of the primary complaint. It would in such cases be absurd to try to bring about a cure by trying to remove the fever.

(vii) To mistake the remote for the proximate cause Many practical errors are due to confusion between the remote and the proximate cause If A instigates B to commit some mischief, it is useless to punish B and thereby be falsely satisfied that the cause of the mischief will disappear.

(viii) To mistake the remote condition as an unconditional cause: This error is embodied in (v.), but as it is specially interesting and a common source of error in historical inductions we should like to have a separate mention of it Napoleon's Russian expedition is often ascribed as the cause of his downfall yet it would not have been so had not the burning of Moscow, the exceptional winter, the rise of the Prussians and Austrians against him, intervened as proximate causes We may take an example from practical and ordinary affairs also The adventures of Captain Scott would never have ended fatally had they not been commenced at all The commencement of such hazardous or rather risky adventures was the remote cause, yet the proximate cause was decidedly a different one. It would be a timid sort of attitude indeed, if remote causes were thus taken into consideration and all adventures discouraged. The fallacy would be the one in question.

6. II c Fallacies due to erroneous Analogies.—Analogies are very useful in suggesting hypotheses. They

may be either partially or wholly wrong. Some examples might be noted to illustrate False Analogy. The argument for or against the independence of a mother-country rests often on a false Analogy. The relations of a colony to a mother-country are analogous to the relations of a child to a mother. A colony it may be inferred from this should never rebel against the mother-country Or sometimes it may be maintained that when the colony attains maturity it should be independent just as the child becomes so when mature. Now in this analogy the points of resemblance are sympathy of race, associations with a common home, gratitude for favours received in earlier stages The points of difference, however, are that in the one relation there is natural affection, in the other it does not exist, in the one there is constant association, in the other it does not exist, and there is nothing like this. Moreover questions of justice or injustice in domestic conduct are always decided by affectionate considerations, whereas there are no such considerations at all in political questions between the colonies and the mother-country. Hence the analogy is an analogy devised to serve selfish interests, at times of the colonies, but very often of the mother-country.

A very common instance of a false Analogy is that between a community and an individual Just as there is growth, maturity, and decay in the case of individuals, so there are these states in communities, and it is argued that all nations that rise are hence bound to fall. Now this is evidently a case of false analogy, and the inference is wrong. For the stage of old age followed by death which occurs in individuals may or may not occur in communties at all. Old age is a necessary consequence of individual life, but decay is not a necessary consequence

of the maturity of communities. The fall of empires resembles death from disease rather than death from old age. Of course, if the social and political condition of a community is in a diseased condition, decay and even death will be the consequence, but not otherwise The Analogy, therefore, does not enable us to arrive at a generalisation, that all nations are bound to have the three stages of individual life in any conditions whatsoever

Aristotle defined virtue as a mean between the extremes of two vices, (one the excess, and the other the defect of any mean). Thus courage is a mean between foolhardiness and timidity, the former being more of the necessary hardihood against physical pains and fears on the battle-field, and the latter being less of it than necessary. All virtues were thus explained as means Evidently this is a false analogy and the inferences therefrom incorrect For the difference between virtue and vice is not simply a difference of *degrees* as the analogy suggests, but a difference of *kind* No amount of softening of vicious conduct can make it a virtuous one, for the real difference between virtue and vice is due to the inner springs of actions, rather than to the visible forms of actions

The argument to prove the existence of God from final causes is an extreme form of a false Analogy There are some resemblances between the bodily organism, its members, and their functions, and the universe as a whole As the different members of the body are subservient to a common plan of functions, so too are the different things in the universe From this the presence of a designer is argued. It would be inconvenient to argue the pros and cons of so impotant an argument as the one to prove God's existence from design in the universe. But

suffice it to say that the analogy is a false one, for there is no reason why God should be assimilated to a human artificer. The motives for the creation of the Universe need not be the same as the motives of human action; the former is perfect or infinite creation, the latter, imperfect or finite one How can we argue from the finite to the infinite? Moreover, the argument contains the fallacy of Misobservation also, for if all things are well-designed in the universe, how is it that certain things are very ill-designed? The existence of the rat is well-designed from the point of view of the cat, but what of the existence of the cat from the point of view of the rat? Is that not a bad design? In this way the argument from design may be shown to rest on a false Analogy, and also to contain erroneous Observation.

A common fallacy of analogy is to regard an analogy as a proof. It is human nature never to be satisfied with the bare collection of facts. We want to *explain* facts If no reason is forthcoming, some people would like to assert "it is *always* so" or "it is so" or "as the proverb has it," . Some reason must be assigned. whether it is valid or not is not considered When it is assigned the mind feels freed as it were of a great burden (namely, the unexplained facts) It is this tendency which is the basis of many false analogies When rational explanations cannot be had, the mind feels satisfied with giving comparisons, as if comparisons are proofs.

QUESTIONS

(1) What is Non-Observation? Give some illustrations of fallacies of Non-observation of Instances and of Circumstances

(2) What is Mal-observation? How do you distinguish Non-Observation and Mal observation?

(3) Enumerate and explain briefly the fallacies of Imperfect Generalisation

(4) Give instances of fallacies due to false Analogy

(5) Show that the same example may be considered as an illustration of two or three fallacies

(6) State with reasons the fallacies, if any, in the following instances —

(*a*) A person in a foreign country meets with four or five ruffians, and from that concludes that all the people of the land are such

(*b*) India is the richest country in the world because the Indians spend much on marriage occasions

(*c*) Whenever civilization advances, poetry declines, because we see it in our days

(*d*) *William Pink Pills* are worth trying, for the advertisements in connection with them contain certificates from various distinguished personages

(*e*) The barking of dogs at midnight predicts evil When a person is dangerously ill, it means, his death will take place This kind of opinion is universal in this country and I noticed this concurrence in some cases I shall therefore believe in this 'ill omen' in this particular case

(*f*) The moral supremacy of India to all other countries is due to the fact that excellent morals were preached by Buddha centuries before there was any civilization in most Western countries,

(*g*) Increase criminal laws, and crimes will increase

(*i*) ' If justice consists in keeping property safe, the just man must be a kind of thief, for the same kind of skill which enables a man to defend property, will enable him to steal it "

(8) How are Analogical arguments at all useful ? To what different causes may arguments be erroneous when they are founded on analogies ? Give one or two examples of fallacies due to erroneous analogies

MISCELLANEOUS QUESTIONS

(1) State and explain the different *modes* of Explanation

(2) Compare and contrast the views of Mill and Hume on causation

(3) Give two examples, one from practical life and one from science, of the different Inductive Methods

(4) How far did Mill succeed in arriving at a satisfactory definition of cause?

(5) What are the difficulties in the application of the Inductive Methods to actual cases

(6) Compare and contrast the views of Mill and Whewell about the nature and function of Induction

(7) What are empirical laws How is it that they are less reliable than laws of Nature?

(8) Distinguish ultimate laws of Nature from Axioms and from Secondary Laws

(9) Is there any Deductive Reasoning in Mill's Canon of Difference? Explain and illustrate the Methods of Agreement and Difference, and estimate their *value* as methods of proof How far are they conclusive

(10) What are the methods for verifying a Hypothesis

(11) How do you distinguish a valid Induction from (1) a legitimate hypothesis, and (2) a good analogy?

12 'A man having been shot through the heart immediately falls dead Investigate the logical value of such a fact as proving that a man shot through the heart will fall dead"

13 Define and explain the law of the Uniformity of Nature Is the converse of that law true?

14 Why are the classifications of Sciences like Botany and Zoology inferior to all other classifications?

15 Are natural classes determined by definition or type

16. Explain and illustrate the following fallacies —

(i) Fallacy of Mal-observation

(ii) Fallacy due to the neglect of a joint cause

(iii) Fallacy due to neglecting the mutuality of cause and effect in certain cases

17 Explain with illustrations the Method of of Residues Would you regard it as an Inductive Method?

18 What are the limits of Scientific Explanation?

19 Prove by the Method of Agreement and Difference that expensive habits are a cause of moral degeneration

20 Under what heads of fallacies would you range the following instances, and why?

(*a*) Indiscriminate submission to the authority of past generations;

(*b*) Indiscriminate submission to the authority of contemporaries,

(*c*) Belief in Alchemy,

(*d*) Belief in Astrology

(*e*) Delusions and Hallucinations,

(*f*) Belief that society like an individual is an organism and as such is subject to the same laws

(*g*) *Belief in mythologies,*

(*i*) Respect for quack doctors

21 Wherein is the Method of Concomitant Variations uncertain?

22 How is it that whenever there is an intermixture of effects it is best to resort to the Deductive Method?

23 How would you as a student of logic carry on the following inquiries?

(*a*) the social degeneracy of the Indians,

(*b*) the effect of the passing of Basu s Bill (which failed)

(*c*) the causes and effects of the recent Bank failures in India

24 Are the laws of Uniformity of Nature and Universal causation inductively established? If so, how far is the proof conclusive?

25 What are the ways by which a Hypothesis is suggested What service does a Hypothesis render?

26 Test the validity of (*a*) the hypothesis that success in life depends on birth at a time when there is a favourable conjunction of heavenly bodies, and (*b*) that plague is due to divine wrath

27 "Facts are familiar theories" Explain and discuss (Carveth Read)

28, Discuss the following statements —

(a) Negatives cannot be proved. (Carveth Read)

(b) A bad proof is worse than no proof

29 'What is meant by the *personal error* (or *personal equation*) in observation? Discuss its importance in different branches of knowledge' (Carveth Read)

30 Why is a single instance, in some cases, sufficient for a complete induction, while in others myriads of concurring instances, without a single exception, known or presumend, go such a very little way towards establishing an universal proposition" (Mill)

31 "What is called the scientific *explanation of a fact* is nothing more than showing it to be a case of a more general fact, which though *more general*, is still a *fact* merely, and is as much in need of 'explanation' as the original fact was" Examine this (Mellone)

HINTS FOR SOLVING THE MISCELLANEOUS QUESTIONS*

Q 1 Resolving the law of a complex effect into the laws of the separate causes, supplying intermediate links of causation in a sequence supposed to be immediate, and subsumption of a given law under a wider one

Q 2 See pages 58-63

Q 5 Would you find it easy to analyse concrete like symbolical cases? If not, the reason of this, is the answer required

Q 9 The canon of Difference implies a principle of *elimination*. Is elimination possible without deduction?

* The hints are intentionally kept terse The student should expound his answers with illustrations, discussions, and so on Very simple questions are left untouched

The remaining question will be found answered in the book itself

Q 11 (1) The result of a good or legitimate Hypothesis is a valid Induction The order of Induction is reversed, in a Hypothesis, for in it we assume a law and then seek facts to verify it, whereas in Induction we first collect facts and then establish a law Start with this basis (2) An Analogy purports to be imperfect proof It may establish certain conclusions like induction, but on diffe-

rent principles The force of good Analogy is decided in a different way from that of a valid Induction Work out the answer from this basis

Q 13 No Take the logical converse of the proposition wh states the law, and find out the reason for yourself

Q 20 Illicit Generalisation, Simple Enumeration (c) and (c) Imperfect Observation Determine the special kind of it Also, imperfect generalisation (f) False Analogy

Q. 21 See the text

Q Whether you should proceed inductively, or take the help of deduction, and if you proceed inductively which data will you require, and what and by which Method will they prove? These are the questions you should try to solve

Q 24 See pp. 34-35, and 62-66

Q 27 What is a fact? Perceptions of facts are inferences applied to impressions on the senses To what extent are not facts theories? Start with this suggestion, and then discuss

Q 28 (a) Is it impossible to prove absence in agreement (b) Is it so? Does it not suggest new hypotheses?

Q 29 Different individuals commit different errors of non-observation and mal observation according to habits, moods, sentiments, and prejudices Dispassionate judgment is almost impossible But the personal equation will affect social, religious, and political problems more than the strictly scientific ones

Q 30 Think of the different Inductive Methods If the instance enables us to examine a *connection between attributes* and thereby establish a causal relation, it would suffice to establish an induction

THE FIGURES REFER TO THE PAGES